United States
Department of
Agriculture

Forest Service

Rocky Mountain
Forest and Range
Experiment Station

Fort Collins,
Colorado 80526

Research Paper
RM-266

# Forest Vegetation of the Arapaho and Roosevelt National Forests in Central Colorado: A Habitat Type Classification

Karl Hess and Robert R. Alexander

## Abstract

A vegetation classification based on concepts and methods developed by R. Daubenmire and refined by others was used to identify 30 forest habitat types on the Arapaho and Roosevelt National Forests. Included were five habitat types in the *Pinus ponderosa* series; four each in the *Pseudotsuga menziesii*, *Pinus contorta*, and *Abies lasiocarpa* series; three each in the *Juniperus scopulorum*, *Pinus flexilis*, and *Populus tremuloides* series; and one each in the *Populus angustifolia*, *Picea pungens*, *Picea engelmannii*, and *Pinus aristata* series. A key to identify the habitat types and the management implications associated with each is provided.


Cover Photo—Ute Pass, Gore Range, Arapaho National Forest

USDA Forest Service
Research Paper RM-266

May 1986

# Forest Vegetation of the Arapaho and Roosevelt National Forests in Central Colorado: A Habitat Type Classification

Karl Hess, Range Resources Specialist
New Mexico Department of Agriculture[1]
and
Robert R. Alexander, Chief Silviculturist
Rocky Mountain Forest and Range Experiment Station[2]

[1]*Headquarters is at New Mexico State University, Las Cruces.*
[2]*Headquarters is in Fort Collins, in cooperation with Colorado State University.*

## Contents

# Forest Vegetation of the Arapaho and Roosevelt National Forests in Central Colorado: A Habitat Type Classification

**Karl Hess and Robert R. Alexander**

This study is the first to comprehensively categorize and describe forest habitat types on the Arapaho and Roosevelt National Forests based on quantitative data.[3] Some of the earlier studies of vegetation on these forests were phytosociologic but limited in scope (Ramaley 1907, 1909; Robbins 1910; Rydberg 1915, 1920). A few more recent studies are relevant to the present study. Marr (1967) described the vegetation of the east slope of the Colorado Front Range from the alpine to the foothills using an ecosystem approach. Dix (1974) reviewed regional ecosystems, and Mutel (1976) provided a popular ecological account of mountain ecosystems. Peet (1978) studied tree population structure as related to succession and environment in the northern Front Range. Adjacent to the Arapaho and Roosevelt National Forests to the north, Alexander et al.[4] described 16 habitat types on the Medicine Bow National Forest. Ten of these occur on the Arapaho and Roosevelt National Forests. West of these forests, Hoffman and Alexander (1980, 1983) described 11 habitat types on the Routt and White River National Forests, respectively. Seven Routt National Forest and 6 White River National Forest habitat types also occur on the Arapaho and Roosevelt National Forests.

Hess (1981) started a study in 1978 to (1) identify and describe forestland, shrubland, and grassland habitat types on the Arapaho and Roosevelt National Forests on the basis of reconnaissance and intensively sampled plots well distributed over both forests, with the exception of the Dillon Ranger District on the Arapaho National Forest;[3] (2) relate habitat types to soils and climatic data; and (3) relate Arapaho and Roosevelt National Forests habitat types to similar classifications of other Rocky Mountain forests. The habitat type clasification completed in 1981 is based on concepts and methods developed by Daubenmire and Daubenmire (1968), Hoffman and Alexander (1976, 1980), Pfister and Arno (1980), and Pfister et al. (1977).

Although Hess (1981) classified grassland, shrubland, and forestland, the results reported here are restricted to forest vegetation. They are intended for two primary audiences—forest managers and land-use planners who want a working tool to use on the Arapaho and Roosevelt National Forests, and ecologists who want a research tool to use in related studies. Not all readers will find each category of information of equal value.

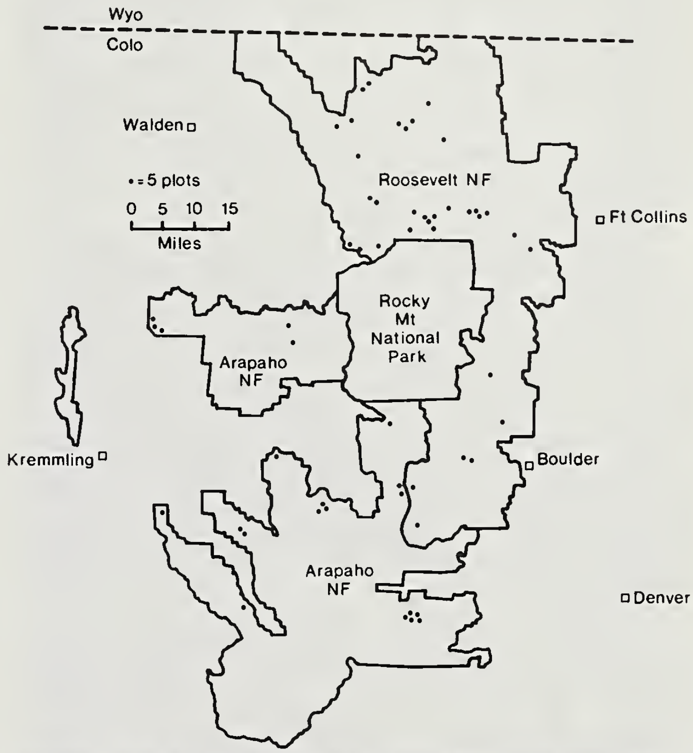


**Figure 1.—Arapaho and Roosevelt National Forests showing location of sample plots.**

## STUDY AREA

The study area, composed of the Arapaho and Roosevelt National Forests,[3] encompasses 2,316,930 acres (912,180 ha) (fig. 1). These forests extend southward from the Wyoming border along the backbone of the Front Range of the northern Colorado Rockies to the Pike and San Isabel National Forests, and westward from the foothills of the Front Range to North Park and the Routt and White River National Forests. Elevations within the study area range from 5,748 feet (1,752 m) in the eastern foothills to 14,258 feet (4,346 m) at the highest point, Mt. Evans, close to the southern boundary.

## PHYSIOGRAPHY AND GEOLOGY

The Front Range, the easternmost mountains of Colorado, are a mosaic of fault-bounded and vertical-uplifted blocks of pre-Cambrian granites, schists, and gneisses, approximately 40 miles (64 km) wide and 185 miles

[3]*Habitat types on the Dillon District of the Arapaho National Forest are included in the classification of forest vegetation on the White River National Forest by Hess and Wasser. In that study, 17 forest habitat types were identified and described. Six of these also occur in the area covered by Hess' (1981) study.*

[4]*Alexander, Robert R., George R. Hoffman, and John M. Wirsing. Forest vegetation of the Medicine Bow National Forest in southeastern Wyoming: A habitat type classification. (Manuscript in preparation.)*

(298 km) long (Weimer and Haun 1960). It extends from its southern terminus at the Arkansas River near Cannon City, Colo. to the Wyoming border, where it divides into two mountain ranges, the Medicine Bow Mountains and the Laramie Range (Chronic and Chronic 1972). The Front Range is bordered on the east by a foothills belt 2 to 4 miles (3 to 6.5 km) wide, which dips steeply eastward forming hogback ridges and gravel-veneered pediments, which interface with the Piedmont section of the Great Plains (Thornbury 1965). The steep topographical rise of the foothills from the plains to the eastern edge of the mountains contrasts sharply with the gradually westward rising Rocky Mountain erosion surface to its crest. The plateau-like slope formed by this gradual rise represents remnants of the Rocky Mountain peneplain—an extensive surface of Paleozoic or younger sedimentary rocks (Vanderwilt et al. 1948).

Subsequent regional uplifting began erosion that removed the sedimentary surface of the peneplain, exposing resistant pre-Cambrian igneous and metamorphic rocks with minor areas of tertiary intrusions and volcanic rock. The differential erosion associated with this uplift accompanied alternating periods of valley cutting, resulting in a highly dissected terrain composed of narrow, deep valleys at lower elevations and glacially broadened, gently sloping valleys at higher elevations (Marr 1967). The glaciation that simultaneously occurred with these events also produced glacial outwash that was carried into the foothills and deposited as gravel caps on Pleistocene surfaces (Wahlstrom 1947).

The westward, upward, and faulted continuation of the Rocky Mountain erosion surface represents the remnants of the flattop peneplain—a series of ridges, which extend westward from the Front Range at elevations 1,500 to 2,000 feet (457 to 610 m) higher than the Rocky Mountain erosion surface (Thornbury 1965). High mountain tops, exceeding 12,000 feet (3,658 m) in elevation, rise from the flattop surface forming a range of glacial sculptured peaks (Lovering and Goddard 1950).

A parallel chain of topographic and structural basins called parks is west of the Front Range. The most prominent of these are North, Middle, and South Parks. The Park Range, which borders the basins on the west, includes the Gore, Tenmile, and Mosquito Ranges. The Gore Range lies south of where the Colorado River dissects the mountain uplift and north of Tenmile Creek that forms the northern boundary of the Tenmile-Mosquito Range. The structure of the Park Range complex is similar to that of the Front Range. However, the presence of fewer resistant sedimentary layers above the pre-Cambrian basement rocks has resulted in a peripheral physiography characterized by less prominently edged and upwardly turned sedimentary layers (Chronic and Chronic 1972). Finally, except for portions of the range immediately west of North Park, the surface of the Park Range is far more plateau-like than is the Front Range.

The crystalline core of the Front Range is essentially pre-Cambrian granite, schist, and gneiss, bordered by steeply tilted sedimentary Paleozoic and Mesozoic rocks, which comprise the eastern foothill belt (Lovering and Goddard 1950). Included in the crystalline core are high grade meta-sedimentary beds, layered meta-igneous rock, and quartzites. However, granite rock comprises about two-thirds of the pre-Cambrian complex. Large batholiths consisting of Pikes Peak granite in the south and Sherman granite in the north form the two ends of the Front Range (Thornbury 1965).

The central portions of the Front Range are composed of Georgetown granite and small plutons, which are enclosed by various gneisses, schists, and quartzites (George 1920). Although Pleistocene uplifts and subsequent erosions have removed much of the Paleozoic and younger sedimentary rocks that once covered the crystalline core, isolated sedimentary rock is widespread throughout the Front Range (Dix 1974). Finally, Pleistocene glaciation has left appreciable surface areas covered by glacial deposits (Wahlstrom 1947). The geological composition of the Park Range is similar to that of the Front Range—upward faulted blocks of pre-Cambrian granite. Tertiary volcanic features, including dikes and lava flows, are also evident in the northern portions of the range. Although Paleozoic sedimentary rocks have been eroded from the eastern flank of the Park Range as far south as the Gore Range, they are present throughout the higher elevations of the Tenmile and Mosquito Ranges (Chronic and Chronic 1972).

## CLIMATE

In general, the forestland on the Roosevelt National Forest on the east slope of the Continental Divide is drier and warmer than comparable forestlands on the Arapaho National Forest west of the Continental Divide. For example, mean annual precipitation varies from about 18 to 21 inches (48 to 53 cm) in the *Pinus contorta* zone at 8,500 feet (2,590 m), on the east slope of the divide, and 20 to 25 inches (51 to 64 cm) at comparable elevations on the west slope of the divide (Haeffner 1971; Marr 1968a, 1968b). In the *Picea engelmannii-Abies lasiocarpa* zone, mean annual precipitation on the east slope varies from 25 to 30 inches (64 to 76 cm), and on the west slope from 30 to 35 inches (76 to 89 cm) at 10,500 feet (3,050 m) elevation.

Mean annual July temperatures in the *Pinus contorta* zone on the east slope is about 64 °F (18 °C), with a January mean of 22 °F (–6 °C). On the west slope, mean annual July temperatures are 61 °F (16 °C), with a January mean of 18 °F (–8 °C). In the *Abies lasiocarpa-Picea engelmannii* zone, mean annual July temperatures on the east slope are 55 °F (13 °C), with a January mean of 19°F (–7 °C). On the west slope, mean annual July temperatures are 54 °F (12 °C), with a January mean of 15 °F (–9 °C) (Haeffner 1971; Marr 1968a, 1968b).

The temperature and precipitation data from published records are useful in characterizing the Arapaho and Roosevelt National Forests in broad, general terms. However, in regions with massive mountain ranges, deep valleys and canyons, and high plateaus, precipitation and temperatures are so variable that it is difficult to provide any meaningful climatic information for a given locality.

## METHODS

Preliminary work began in 1978, with a reconnaissance survey systematically made through all vegetation types to select mature, relatively undisturbed stands across as many environmental gradients as possible. The choice of reconnaissance stands was done subjectively but without preconceived bias—a method recommended by Mueller-Dombois and Ellenberg (1974). At each site, plants present were listed, their cover-abundance was noted, successional status of the stand and dominant tree species were estimated, and study sites were noted, with brief descriptions of physiographic factors. The first approximation of potential habitat types was made by analysis of the reconnaissance data; study plots were chosen for intensive sampling based on this initial delineation of potential habitat types.

During the summers of 1979 and 1980, 123 forest stands were intensively sampled. Those stands were mostly old growth and climax or in the late stages of seral succession. Old-growth stands were not available in every locality because of extensive past disturbance by fire, insects, logging, and grazing. Plots for intensive sampling were placed in stands only on sites judged to have the most homogeneity in environmental and floristic characteristics and the least ecotonal effects. Stands were representative of the forest communities characterized by the following tree species: *Juniperus scopulorum*, *Pinus ponderosa*, *Pseudotsuga menziesii*, *Picea pungens*, *Pinus flexilis*, *Pinus contorta*, *Populus tremuloides*, *Populus angustifolia*, *Abies lasiocarpa*, *Picea engelmannii*, and *Pinus aristata*.

In each stand, a 49.2- by 82.0-foot (15- by 25-m) plot was laid out with the long axis parallel to the contour to minimize ecotonal effects. Each main plot then was subdivided into three 16.4- by 82.0-foot (5- by 25-m) subplots. Within each 4,036-square-foot (375-m$^2$) main plot, all trees taller than 3.28 feet (1 m) were measured and recorded by eight 0.328-foot (1-dm) diameter classes. Trees less than 3.28 feet (1 m) tall were counted and recorded by three height classes in two 3.28- by 82.0-foot (1- by 25-m) transects along the inner sides of the central subplot.

Canopy coverage of all understory shrubs, forbs, and graminoids was estimated on forty 7.9- by 19.7-inch (2- by 5-dm) microplots placed systematically along the inner sides of the central subplot. Canopy coverage of each species was recorded as one of 12 cover classes (0–2%, 3–6%, 7–10%, 11–20%, 21–30%, 31–40%, 41–50%, 51–60%, 61–70%, 71–80%, 81–90%, and 91–100%). Also listed were those species not occurring in the 40 microplots but present in the 4,036-square-foot (375-m$^2$) main plot.

Finally, in the center of each main plot, a soil pit was dug to facilitate a standard soil profile description (USDA Soil Conservation Service 1951). Soil texture was determined by the LaMotte soil texture field kit. Determination of pH (A horizon only) was made with the LaMotte-Morgan field pH test set. Munsell color charts were used to identify soil colors. Taxonomic descriptions of the soils were based on USDA Soil Conservation Service (1975).

## ANALYSIS OF DATA

Tree size class data were combined according to habitat type, and mean values for each size class within each habitat type were calculated (table A–1).

For each microplot examined, the midpoints of the coverage classes were used to calculate average percent coverage for each shrub, graminoid, and forb species. Constancy also was determined for each species. Mean coverage and constancy data for all understory species are shown in appendix tables A–2 through A–12. Species coverage and selected stand characteristics then were transferred to an association table. Stand data were arranged and rearranged to group stands with similar floristic composition and climax tree species. Initial habitat type separation was based on consideration of tree overstory and major understory shrubs, graminoids, and forbs (Daubenmire 1952, Daubenmire and Daubenmire 1968, Mueller-Dombois and Ellenberg 1974).

The habitat types initially partitioned by association table methodology were quantitatively verified using similarity indexes (Mueller-Dombois and Ellenberg 1974). Greater similarity of stands within habitat types was separated originally by association tables. Equivalent or lesser similarity of stands within habitat types than between habitat types required reanalysis of association table data to determine whether the initial habitat type delineation was justified on either a floristic or environmental basis. Thirty forest habitat types in 11 series were delineated by this two-tiered analysis (Hess 1981).

Nomenclature for plants collected in this study primarily follows Harrington (1954). Although plants were collected at various times during the growing season, some taxonomic difficulties persisted. Most of these resulted from hybridization among two or more species which have not been studied systematically to clarify the taxonomy. Other taxonomic difficulties related to lack of flowering specimens. Where considerable variation made it impossible to determine species, only genera were used.

## ECOLOGIC TERMS AND CONCEPTS

Because terminology in ecology is not uniformly used or understood, the terms and concepts used in this paper are defined. Unless stated otherwise, all terms follow usage proposed by Daubenmire and Daubenmire (1968).

"Climax vegetation" is that which has attained a steady state with its environment; without disturbance, species of climax vegetation successfully maintain their population sizes. The following classification of climax vegetation was first proposed by Tansley (1935). Daubenmire (1968) further elaborated on the definition, usage, and limitations. "Primary climaxes" develop on habitats where recurring disturbance is not a factor influencing the structure or composition of the vegetation. "Climatic climax" vegetation develops on normal topography with fairly deep, well-drained, loamy soil. Normal topography in mountainous regions is necessarily different from that of plains regions. Where soils or topography exert sufficient influence to produce self-perpetuating vegetation distinct from the climatic climax, the terms "edaphic climax" and "topographic climax," respectively, are used to describe the steady-state vegetation. Where special topographic conditions also favor the development of edaphic conditions distinct from the normal, the term "topo-edaphic climax" is often used in descriptions of the resulting steady-state vegetation.

Where recurring disturbance, such as grazing or fire, has a predominant influence on the composition or structure of steady-state vegetation, the term "disclimax" is used. Two common disclimaxes are the "zootic climax" and the "fire climax." Without disturbance(s), the vegetation may revert to the primary climax.

Habitat type is the basic unit in classifying lands or sites based on potential (climax) natural vegetation. A habitat type represents, collectively, all parts of the landscape that support, or have the potential of supporting, the same climax vegetation. Series is the next higher category of classification (Hoffman and Alexander 1976); each habitat type is named for its (climax) plant association. For example, all habitat types with *Pinus ponderosa* as the potential climax dominant are grouped into the *Pinus ponderosa* series. The series is more than an artificial grouping of habitat types using the potential climax overstory dominant as the convenient thread of continuity. There is an ecologic basis for grouping habitat types into series.

For example, *Pinus ponderosa* occupies areas warmer and drier than areas where *Pseudotsuga menziesii* is climax. Continuing higher into the mountains, *Populus tremuloides*, *Pinus contorta*, *Abies lasiocarpa*, and *Picea engelmannii* successively become the dominant species. In the absence of adequate climatic data for the Arapaho and Roosevelt National Forests, it is assumed that these self-perpetuating populations of dominant trees are related to the macroclimate, whereas the undergrowth vegetation is related more to microclimate and soils. Stands in a series have the same general appearance whether they are in the Arapaho and Roosevelt National Forests or in nearby forests of Colorado and Wyoming (Hoffman and Alexander 1980, 1983; Alexander et al.[4]).

Habitat types within a series are distinguished on the basis of undergrowth vegetation. For example, *Populus tremuloides* is widely distributed as a seral and climax species in Colorado. Where it is climax, several undergrowth unions occur. The most luxuriant and widely distributed is the *Thalictrum fendleri* union. On some sites, a union formed by the single species *Carex geyeri* forms a conspicuous layer. Where *Carex geyeri* dominates the undergrowth, it forms another habitat type. Thus, *Populus tremuloides/Thalictrum fendleri* and *Populus tremuloides/Carex geyeri* are two distinct habitat types even though *Carex geyeri* may be well-represented in both.

The Arapaho and Roosevelt National Forests have been disturbed by fire, logging, and grazing for many years. Because of these disturbances, not all of the land area currently supports climax vegetation. Much of the area of a habitat type may never attain climax status. Nevertheless, it is important to consider land units in terms of their potential status, because classification by climax vegetation results in the most significant biogeographic classification of the land surface (Daubenmire 1952). The practical value of habitat type classifications is only beginning to be realized in areas of mapping tree productivity, disease and insect susceptibility, potential for producing forage and browse, soil moisture depth, and tree regeneration (Arno and Pfister 1977; Daubenmire 1961, 1973; Layser 1974; Monserud 1984; Pfister 1972). The habitat type concept offers a useful approach to managing forest resources.

## FOREST HABITAT TYPES

Forest vegetation in the Arapaho and Roosevelt National Forests ranges from the xerophytic *Juniperus scopulorum*-dominated vegetation at the warmer, drier low elevations to the mesophytic *Abies lasiocarpa-Picea engelmannii*-dominated vegetation at the cooler, moister high elevations.

## *JUNIPERUS SCOPULORUM* SERIES

The *Juniperus scopulorum* series occurs only along portions of the eastern flank of the northern Front Range of Colorado, on the Roosevelt National Forest. The habitat types of this series occur on all aspects, at elevations ranging from 6,150 to 8,530 feet (1,875 to 2,600 m). They are specific to exposed boulder and rock outcroppings on moderate to steep slopes of the foothills and montane zones (table 1).

The *Juniperus scopulorum* series was sampled in 12 plots and 3 habitat types. *J. scopulorum* is a climatic climax in two habitat types and a topographic climax in the other habitat type. Basal areas on the study plots ranged from 10 to 33 square feet per acre (2 to 8 $m^2/ha$). Tree sizes range from seedlings to the 12- to 16-inch (3- to 4-dm) d.b.h. class. Tree populations and undergrowth data for *Juniperus scopulorum* stands are shown in tables A–1 and A–2. Distribution of habitat types within this series in the western United States is poorly known, because most forested habitat type studies do not include this series.

### *Juniperus scopulorum/Cercocarpus montanus*

#### Description

The *Juniperus scopulorum/Cercocarpus montanus* habitat type is represented by four stands. It is found in all districts of the Roosevelt National Forest, on steep (45–65%) exposed, rocky, mostly northeast- to northwest-facing slopes. Soils in this habitat type, mostly Entisols (Lithic and Typic Ustorthents), are coarse and shallow, derived from colluvial and residual parent materials of gneiss, schist, and granite (table 1). This topographic climax is the most xeric forest habitat type in the Roosevelt National Forest. Open-grown *J. scopulorum* dominate the tree stratum, with a few widely scattered individuals of *Pinus ponderosa* and *Pseudotsuga menziesii*. The understory is dominated by *C. montanus*

Table 1.—Selected topographic and edaphic characteristics in the Arapaho and Roosevelt National Forests.

| Habitat type | Number of stands sampled | Elevation (m) | Soil texture | Depth of solum (cm) | pH | Coarse fragments (%) |
|---|---|---|---|---|---|---|
| *Juniperus scopulorum/ Cercocarpus montanus* | 4 | 1928–2115 | Sandy loam | 7–18 | 6.6–7.2 | 35–40 |
| *Juniperus scopulorum/ Purshia tridentata* | 4 | 2158–2499 | Sandy loam | 6–22 | 6.6–6.8 | 33–45 |
| *Juniperus scopulorum/ Artemisia tridentata* | 4 | 2390–2524 | Loamy sand-sandy loam | 4–20 | 7.0–7.6 | 45–55 |
| *Populus angustifolia/ Salix exigua* | 4 | 2048–2341 | Sandy loam-silt loam | 26–41 | 6.2–7.4 | 0–10 |
| *Pinus ponderosa/ Cercocarpus montanus* | 4 | 1926–2134 | Loamy sand-sandy loam | 7–15 | 5.6–7.0 | 20–60 |
| *Pinus ponderosa/ Purshia tridentata* | 4 | 2335–2658 | Sandy loam | 14–32 | 6.2–6.6 | 20–55 |
| *Pinus ponderosa/ Muhlenbergia montana* | 4 | 2420–2624 | Loamy sand-sandy loam | 11–25 | 6.2–6.8 | 35–50 |
| *Pinus ponderosa/ Carex rossii* | 5 | 1896–2451 | Sandy loam-loam | 6–53 | 6.0–6.7 | 5–55 |
| *Pinus ponderosa/ Hesperochloa kingii* | 4 | 2240–2548 | Sandy loam-sandy clay loam | 9–68 | 5.8–6.6 | 0–55 |
| *Pseudotsuga menziesii/ Carex rossii* | 4 | 1792–1902 | Sandy loam | 6–38 | 6.8 | 20–50 |
| *Pseudotsuga menziesii/ Carex geyeri* | 4 | 2365–2505 | Sandy loam-silt loam | 13–32 | 6.2–6.6 | 5–30 |
| *Pseudotsuga menziesii/ Physocarpus monogynus* | 4 | 1817–2396 | Sandy loam-sandy clay loam | 8–58 | 6.3–6.6 | 25–60 |
| *Pseudotsuga menziesii/ Jamesia americana* | 4 | 2201–2241 | Sandy loam-loam | 8–36 | 6.2–6.8 | 25–60 |
| *Picea pungens/ Arnica cordifolia* | 4 | 2289–2707 | Sandy loam-sandy clay loam | 17–71 | 6.0–6.6 | 0–20 |
| *Populus tremuloides/ Festuca thurberi* | 4 | 2664–2838 | Sandy loam-silt loam | 16–39 | 6.0–6.6 | 4–55 |
| *Populus tremuloides/ Carex geyeri* | 4 | 2475–2780 | Sandy loam-silt loam | 9–45 | 6.0–6.2 | 0–45 |
| *Populus tremuloides/ Thalictrum fendleri* | 4 | 2758–2883 | Sandy loam-clay loam | 11–74 | 6.4–7.0 | 0–20 |
| *Pinus flexilis/ Juniperus communis* | 4 | 2576–2780 | Sandy loam | 6– 9 | 6.2–6.8 | 40–55 |
| *Pinus flexilis/Calamagrostis purpurascens* | 4 | 2981–3353 | Sandy loam | 4–11 | 6.2–6.8 | 30–40 |
| *Pinus flexilis/ Trifolium dasyphyllum* | 4 | 3368–3490 | Sandy loam | 6–15 | 5.4–6.8 | 35–45 |
| *Pinus contorta/ Juniperus communis* | 4 | 2573–2728 | Sandy loam-sandy clay loam | 12–47 | 5.4–6.2 | 15–55 |
| *Pinus contorta/ Carex geyeri* | 4 | 2554–2798 | Sandy loam-silt loam | 8–51 | 5.4–6.4 | 1–55 |
| *Pinus contorta/ Shepherdia canadensis* | 5 | 2554–2755 | Loamy sand-sandy clay loam | 18–63 | 5.4–6.0 | 0–45 |
| *Pinus contorta/ Vaccinium scoparium* | 4 | 2822–3072 | Sandy loam-loam | 6–14 | 5.4–6.0 | 30–45 |
| *Picea engelmannii/ Trifolium dasyphyllum* | 4 | 3316–3438 | Loamy sand-sandy loam | 6–24 | 5.2–5.8 | 5–40 |
| *Abies lasiocarpa/ Carex geyeri* | 4 | 2755–3142 | Loam-clay loam | 8–46 | 5.4–6.2 | 0–40 |
| *Abies lasiocarpa/ Vaccinium scoparium* | 5 | 2871–3402 | Sandy loam-loam | 7–51 | 4.6–5.2 | 10–35 |
| *Abies lasiocarpa/ Senecio triangularis* | 4 | 2981–3383 | Sandy loam-silt loam | 10–49 | 5.4–6.0 | 20–50 |
| *Abies lasiocarpa/ Calamagrostis canadensis* | 4 | 2786–3048 | Sandy loam-silt loam | 10–41 | 6.0–6.6 | 0–50 |
| *Pinus aristata/ Trifolium dasyphyllum* | 4 | 3499–3542 | Sandy loam-silt loam | 8–11 | 5.6–6.2 | 15–30 |

(18–22% coverage) (fig. 2). Other important shrubs are *Ribes cereum*, *Rubus deliciosus*, *Artemisia frigida*, and *Opuntia polyacantha*. Significant graminoids are *Agropyron griffithsii*, *Poa sandbergii*, and *Stipa comata*. Major forbs include *Achillea lanulosa*, *Allium textile*, *Heuchera bracteata*, *Penstemon virens*, and *Potentilla fissa*.

Although *J. scopulorum* is widespread throughout the Rocky Mountains, the *J. scopulorum/C. montanus* habitat type has not previously been reported elsewhere. Hess and Wasser[5] did report a *Juniperus osteosperma/C. montanus* habitat type on the White River National Forest; but the characteristics of this habitat type are different from the *J. scopulorum/C. montanus* habitat type on the Roosevelt National Forest.

### Management Implications

This very dry habitat has low potential for timber production (fuelwood), because growth is very slow and trees are widely spaced. Livestock forage production is moderately low. Slopes are generally too steep for either timber harvesting or livestock grazing. The *Juniperus scopulorum/Cercocarpus montanus* habitat type is moderately important to very important as mule deer winter range because *C. montanus* can be a significant food source. Overstory trees adjacent to grasslands may provide cover for a variety of wildlife. It has no potential for increasing water production, but does provide watershed cover.

## *Juniperus scopulorum/Purshia tridentata*

### Description

The *Juniperus scopulorum/Purshia tridentata* habitat type was sampled in four stands. This dry habitat type is confined to the northern part of the Roosevelt National Forest. It occurs on steep (50–75%) east-, south-, and west-facing slopes characterized by rock and boulder outcroppings. Soils are Entisols and Mollisols (Typic Ustorthents and Entic Haploborolls). They are coarse-textured and shallow, derived from colluvial and residual gneissic and schistic rock (table 1). Parent material is commonly exposed at the ground surface. Although *Pinus ponderosa* and *Pseudotsuga menziesii* are occasional components, *J. scopulorum* dominates the overstory (fig. 3). *P. tridentata* (16–20% coverage) is the dominant understory species. *Rubus deliciosus*, *Artemisia frigida*, *Leptodactylon pungens*, and *Opuntia polyacantha* are important shrub associates. Important graminoids include *Agropyron griffithsii*, *Carex rossii*, *Muhlenbergia montana*, and *Stipa comata*. Among the constant forbs present are *Chrysopsis villosa*, *Eriogonum umbellatum*, *Helianthus pumilus*, and *Potentilla fissa*. Cover of graminoids and forbs is usually higher than for other *Juniperus scopulorum*-dominated habitat types. The *J. scopulorum/P. tridentata* habitat type has not been identified elsewhere.

[5]*Hess, Karl, and Clinton H. Wasser. Grassland, shrubland, and forestland habitat types on the White River-Arapaho National Forests. (Final report.)*

**Figure 2.—*Juniperus scopulorum/Cercocarpus montanus* habitat type. *Pinus ponderosa* is visible in the background at the right.**

**Figure 3.—*Juniperus scopulorum/Purshia tridentata* habitat type. Large boulder outcropping are typical of this habitat type.**

### Management Implications

This is also a dry habitat type on steep slopes. The management implications for timber, livestock forage, and water yield are the same as for the *Juniperus scopulorum/Cercocarpus montanus* habitat type. Because *P. tridentata* is highly palatable to mule deer, this habitat type is potentially very important big game winter range. It also has value as cover for other wildlife and watershed protection.

## *Juniperus scopulorum/Artemisia tridentata*

### Description

The *Juniperus scopulorum/Artemisia tridentata* habitat type, represented by four plots, is confined to the far northern part of the Roosevelt National Forest, on steep to very steep (45–75%) south-facing rocky slopes. Soils are Entisols and Haploborolls (Typic Ustorthents and Entic Haploborolls). They are colluvium and residuum derived from gneiss and schist, with parent material frequently exposed at the ground surface (table 1). The overstory is dominated by *J. scopulorum* and the understory by *A. tridentata* (fig. 4). Other tree species include *Pinus ponderosa* and *Pseudotsuga menziesii*. *Ribes cereum* is the only other shrub with high constancy. The important herbaceous species are *Elymus ambiguus*, *Oryzopsis hymenoides*, *Oryzopsis micrantha*, *Eriogonum umbellatum*, *Phacelia heterophylla*, and *Pulsatilla ludoviciana*. Graminoids have a higher cover percentage than forbs. The *J. scopulorum/A. tridentata* habitat type has not been identified elsewhere.

### Management Implications

This dry habitat type also has low potential for timber, water, and livestock forage production. It is not particularly valuable for wildlife, although it may provide cover for wildlife when adjacent to grasslands; but it provides watershed protection.

## *PINUS PONDEROSA* SERIES

The *Pinus ponderosa* series occurs on much of the land area in the montane zone of the eastern slope of the Front Range in northern Colorado, on the Roosevelt National Forest. This series occurs on a variety of aspects at elevations ranging from 6,235 to 8,860 feet (1,900 to 2,700 m) within environments wetter than those associated with the *Juniperus scopulorum* series (table 1).

The *Pinus ponderosa* series was sampled in 21 plots representing five habitat types. Basal areas on the study plots ranged from 41 to 207 square feet per acre (9 to 48 $m^2$/ha). Tree sizes ranged from seedlings to the 20- to 24-inch (5- to 6-dm) d.b.h. class. Tree populations and undergrowth data for *Pinus ponderosa* stands are shown in tables A–1 and A–3.

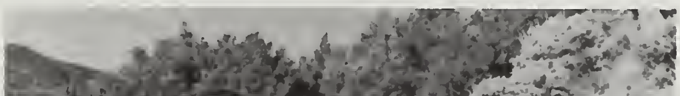

**Figure 4.—*Juniperus scopulorum/Artemisia tridentata* habitat type. Parent rock material is abundant on the soil surface at this site.**

**Figure 5.—*Pinus ponderosa/Cercocarpus montanus* habitat type. *C. montanus* is well represented throughout the understory of this stand.**

### *Pinus ponderosa/Cercocarpus montanus*

### Description

The *Pinus ponderosa/Cercocarpus montanus* habitat type is represented by four stands. It is a major forest habitat type of the foothills and lower montane zones that commonly occurs on all districts of the Roosevelt National Forest. The *P. ponderosa/C. montanus* habitat type occurs predominately on moderate to steep (35–60%) southeast- to southwest-facing slopes. It occupies one of the driest environments of the *P. ponderosa* series. Soils are Entisols and Inceptisols (Typic Ustochrepts and Typic Ustorthents). They are shallow, coarse-textured colluvium derived from gneiss, schist, and granite, and considerable parent material is exposed at the ground surface (table 1). *P. ponderosa/C. montanus* is recognized by the consistent presence and limited reproductive success of *P. ponderosa* and the abundance and dominance of *C. montanus* (10–17% coverage) in the undergrowth (fig. 5). *Pseudotsuga menziesii*, with low constancy, it the only tree associate.

In addition to *C. montanus*, other important shrubs are *Artemisia frigida* and *Opuntia polyacantha*. The major herbaceous species include *Agropyron griffithsii*, *Carex rossii*, *Koeleria cristata*, *Allium textile*, *Eriogonum umbellatum*, *Geranium fremontii*, and *Leucocrinum montanum*. The *P. ponderosa/C. montanus* habitat type has not been reported elsewhere by investigators using standard habitat type classification methodology (Alexander 1985).

### Management Implications

This dry habitat type has low potential for timber production because of the open-grown character of the *P. ponderosa* overstory, steep slopes, and low site quality. Forage production potential is low for livestock on these sites. This habitat type has moderately high value as bighorn sheep and mule deer winter range, providing both food and cover. The *P. ponderosa/C. montanus* habitat type has no potential for increasing water yield but does provide watershed protection.

### *Pinus ponderosa/Purshia tridentata*

#### Description

The *Pinus ponderosa/Purshia tridentata* habitat type, represented by four stands, is a major habitat type of the montane zone in the northern part of the Roosevelt National Forest. This dry habitat type is commonly found on gentle to steep (10–55%) south-facing slopes. Soils, mostly Alfisols (Mollic Eutroboralfs), are colluvium derived from metamorphic and igneous rock that are relatively deep and well-drained (table 1). The overstory of the *P. ponderosa/P. tridentata* habitat type is dominated by open-grown *P. ponderosa*, with *Juniperus scopulorum* and *Pseudotsuga menziesii* common tree associates. The undergrowth is dominated by *P. tridentata* (23–26% coverage) (fig. 6). *Arctostaphylos uva-ursi, Juniperus communis*, and *Ribes cereum* are important associated shrubs. Major graminoids include *Carex rossii, Hesperochloa kingii*, and *Muhlenbergia montana*. Important forbs are *Achillea lanulosa, Geranium fremontii, Mertensia lanceolata, Penstemon virens*, and *Sedum stenopetalum*.

Daubenmire and Daubenmire (1968) in eastern Washington and northern Idaho, Pfister et al. (1977) in Montana, Steele et al. (1981) in central Idaho, and Youngblood and Mauk (1985) in southern Utah all reported a *P. ponderosa/P. tridentata* habitat type; but the graminoid and forb composition is different from the *P. ponderosa/P. tridentata* habitat type on the Roosevelt National Forest.

#### Management Implications

Timber productivity potential in the *P. ponderosa/P. tridentata* habitat type is very low, and tree regeneration is difficult to obtain, especially on disturbed soils. Forage production potential for livestock is moderate to low because of low precipitation. This habitat type has the potential to be excellent quality winter range for mule deer and elk. Partial cutting increases the shrub and herbaceous layers, improving both diversity and forage production. Deer also use the habitat type for food and hiding cover in the summer. It also is a highly preferred habitat for the mountain cottontail (Cayot 1978). *P. tridentata* is usually slow to recover from fire; burning tends to increase graminoids and forbs, thereby improving the forage value for livestock and elk at the expense of deer. The *P. ponderosa/P. tridentata* habitat type has no potential to increase water yield but does provide watershed protection.

**Figure 6.—*Pinus ponderosa/Purshia tridentata* habitat type. Extensive stands in this habitat type are found throughout the montane zone of the Roosevelt National Forest.**

**Figure 7.—*Pinus ponderosa/Muhlenbergia montana* habitat type. Stands in this habitat type are typically open, having sparse understories and extensive areas of bare soil.**

### *Pinus ponderosa/Muhlenbergia montana*

#### Description

The *Pinus ponderosa/Muhlenbergia montana* habitat type was sampled in four stands. It is a minor habitat type found only in the central and southern Roosevelt National Forest. The habitat type occurs on exposed hilltops and moderate to steep (40–65%) south-facing slopes. Soils are Entisols and Mollisols (Typic Ustorthents, and Entic and Typic Haploborolls). They are shallow and coarse-textured derived from decomposed granite, which distinguishes this habitat type from the *P. ponderosa/Cercocarpus montanus* and *P. ponderosa/Purshia tridentata* habitat types (table 1). Considerable area is in bare soil and exposed rock and gravel. The overstory of the *P. ponderosa/M. montana* habitat is dominated by very open-grown *P. ponderosa* and undergrowth dominated by *M. montana* (5–17% coverage) (fig. 7). Scattered *Juniperus scopulorum* and *Pseudotsuga menziesii* are minor but constant components of the overstory, and *Pinus flexilis* may occur occasionally. The shrub layer contains widely scattered individuals of *Artemisia frigida, Opuntia polyacantha, Ribes cereum*, and *Rubus deliciosus*. Important graminoids are *Agropyron griffithsii, Hesperochloa kingii, Muhlenbergia filiculmis*, and *M. montana*. Major forbs include *Achillea lanulosa, Chrysopsis villosa, Eriogonum umbellatum*, and *Geranium fremontii*.

A similar *P. ponderosa/M. montana* habitat type has been reported in central and southern Utah (Youngblood and Mauk 1985), northern New Mexico and southern Colorado (DeVelice et al. 1986), central and southern New Mexico (Alexander et al.,[6] Fitzhugh et al.[7]), and eastern Arizona (Fitzhugh et al.[7]).

### Management Implications

The potential for timber production in this habitat type is low to very low because of low stand density and very poor site quality. *P. ponderosa* regeneration is random and irregular, and success is not improved by seedbed preparation. Forage production for livestock is moderate. *M. montana* is highly palatable to cattle; but overgrazing may cause serious degradation of the site. Susceptibility to dwarf mistletoe is high in this habitat type. The habitat type has high potential for early winter or transitional range for bighorn sheep. The *P. ponderosa/M. montana* habitat type has no potential for increasing water yield but does provide watershed protection.

## *Pinus ponderosa/Carex rossii*

### Description

The *Pinus ponderosa/Carex* rossii habitat type, represented by five stands, occurs throughout the Roosevelt National Forest but occupies only small areas in any one place. The habitat type commonly occurs on gentle to moderate (5–35%) slopes on variable aspects at higher elevations and northerly aspects at lower elevations. Soils are Entisols and Alfisols (Typic Ustorthents and Typic Eutroboralfs). They are alluvium and colluvium developed from sedimentary, metamorphic, or igneous rocks that are moderately deep, well-drained, sandy loams (table 1). The overstory of the *P. ponderosa/C.* rossii habitat type is dominated by relatively closed and moderately vigorous stands of *P. ponderosa. Juniperus scopulorum* and *Pseudotsuga menziesii* are minor and infrequent components of the overstory. *C. rossii* (7–16% coverage) dominates the understory (fig. 8); but all undergrowth is sparse. *Cercocarpus montanus* and *Juniperus communis* are the only associated shrub species of high constancy. Important graminoids, in addition to *C. rossii*, are *Koeleria cristata* and *Muhlenbergia montana*. Major forbs include *Harbouria trachypleura* and *Mertensia lanceolata*. The *P. ponderosa/C. rossii* habitat type has been reported on the Medicine Bow National Forest in southeastern Wyoming (Alexander et al.[4]). A similar habitat type has been observed on the Pike National Forest south of the Roosevelt National Forest (Alexander 1985).

[6] *Alexander, Billy G., Jr., E. Lee Fitzhugh, Frank Ronco, Jr., and John A. Ludwig. A classification of forest habitats of the Cibola National Forest, New Mexico. (Manuscript in preparation.)*

[7] *Fitzhugh, E. Lee, William H. Moir, John A. Ludwig, and Frank Ronco, Jr. Forest habitat types in the Apache, Gila, and part of the Cibola National Forests. (Manuscript in preparation.)*

**Figure 8.—*Pinus ponderosa/Carex rossii* habitat type. *P. ponderosa* regeneration is present in the center of this stand.**

### Management Implications

This habitat type has low potential for timber and water production; soils are well-drained to excessively well-drained. Although *Muhlenbergia montana* and *Koeleria cristata* are highly palatable to cattle, the potential for increasing forage production is also low, because undergrowth is sparse. Cutting should be restricted to light or modified shelterwood that protects the site and reduces the possibility of *C. rossii* increasing at the expense of more palatable graminoids. *P. ponderosa* regeneration is difficult to obtain, especially in dry years and on disturbed soils. Moreover, *C. rossii* is likely to increase on disturbed soils. Although a variety of wildlife occasionally use this habitat type, the potential for improving wildlife habitat is moderate to low. However, any timber harvesting in this habitat type is likely to provide more forage for big game but will reduce cover.

## *Pinus ponderosa/Hesperochloa kingii*

### Description

The *Pinus ponderosa/Hesperochloa kingii* habitat type, represented by four stands, is distinguished by the dominance of *P. ponderosa* in the overstory and *H. kingii* in the undergrowth (fig. 9). This is a major habitat type throughout the Roosevelt National Forest. The *P. ponderosa/H. kingii* habitat type typically occurs on gentle to moderate (10–40%) slopes on all but south aspects. Soils are principally Alfisols (Mollic Eutroboralfs). They are usually moderately deep, well-drained loams developed in place from metamorphic and igneous rocks (table 1). Scattered *Pseudotsuga menziesii* and *Pinus flexilis* occur in relatively closed and moderately productive *P. ponderosa* overstory. Undergrowth vegetation is sparse and poorly developed. *Artemisia frigida* and *Ribes cereum* are the common shrubs, *H. kingii* (5–16% coverage) is the principal graminoid, and *Allium geyeri, Geranium fremontii, Harbouria trachypleura*, and *Sedum stenopetalum* are the primary forbs.

The P. ponderosa/H. kingii habitat type has not been reported elsewhere by investigators using standard habitat type methodology (Alexander 1985).

### Management Implications

Potential for timber productivity is moderate. Standard and group shelterwood can be used to regenerate this habitat type (Alexander 1986c). Natural regeneration usually is adequate with good seed years and site preparation. Partial cutting will increase the proportion of *H. kingii*. Clearcutting will increase the proportion of forbs while retaining a good representation of *H. kingii*. However, it may be difficult to regenerate this habitat type after clearcutting, especially on disturbed soils. Uneven-aged management with individual-tree and/or group selection cutting methods will accomplish the same thing as shelterwood cutting but may be more difficult and costly to implement (Alexander 1986c). The potential for forage production for livestock is moderate. *H. kingii* is very palatable to cattle; and any timber harvesting method that increases it improves forage production. The potential for improving big game habitat is low; but this habitat type provides food and cover to Abert squirrels. The potential for increasing water yields is low; but the habitat type provides watershed protection.

## *PSEUDOTSUGA MENZIESII* SERIES

The *Pseudotsuga menziesii* series occurs exclusively on steep north-facing slopes of the foothills and montane zones of the Arapaho and Roosevelt National Forests at elevations of 5,470 to 8,530 feet (1,750 to 2,600 m). The habitat types of this series are topographic climaxes specific to the mesic environments of north aspects. The extensive occurrence of the *P. menziesii* series is exceeded only by the *Pinus ponderosa* series, which occupies the xeric environments at the same elevations (table 1). However, the *P. menziesii* series is not confined to the Roosevelt National Forest.

**Figure 9.—*Pinus ponderosa/Hesperochloa kingii* habitat type. *Pseudotsuga menziesii* regeneration can be seen in the background on the right side of this stand.**

**Figure 10.—*Pseudotsuga menziesii/Carex rossii* habitat type. Seral *Pinus ponderosa* is a common associate in immature stands of this habitat type.**

The *Pseudotsuga menziesii* series was sampled in 16 stands representing four habitat types. Basal areas ranged from 96 to 193 square feet per acre (22 to 44 $m^2$/ha). Tree sizes ranged from seedlings to the 16- to 20-inch (4- to 5-dm) d.b.h. class. Tree populations and undergrowth data for the *Pseudotsuga menziesii* stands are shown in tables A–1 and A–4.

### *Pseudotsuga menziesii/Carex rossii*

### Description

The *Pseudotsuga menziesii/Carex rossii* habitat type is represented by four stands. Although it is widely distributed on the Roosevelt National Forest, it is a minor habitat type. The *P. menziesii/C. rossii* habitat type occurs at lower elevations on steep (45–60%) north- to northwest-facing slopes. It occupies the driest sites of the *P. menziesii* habitat types. Soils are primarily Alfisols (Mollic Entroboralfs and Typic Eutroboralfs). They are shallow, coarse-textured, well-drained colluvium derived from gneiss, schist, and granite rocks (table 1). This habitat type is recognized by the overstory dominance of *P. menziesii* and the dominance of *C. rossii* (4–5% coverage) in the undergrowth (fig. 10). *Juniperus scopulorum* and *Pinus ponderosa* are seral tree associates, especially in immature stands. The shrub layer is depauperate, represented by widely scattered individual *Juniperus communis* and *Physocarpos monogynus*. *C. rossii* is the only significant graminoid. Common forbs include *Achillea lanulosa*, *Campanula rotundifolia*, *Cystopterus fragilis*, *Heuchera bracteata*, *Pulsatilla ludoviciana*, and *Saxifraga rhomboidea*. The *P. menziesii/C. rossii* has not been reported elsewhere by investigators using standard habitat type classification methodology (Alexander 1985).

### Management Implications

Potential for timber production is very low. Regeneration of *P. menziesii* and *P. ponderosa* is difficult to obtain because of the dry, well-drained soils. Any timber harvesting in this habitat type should be limited to partial cutting, and soil disturbance should be minimized. Overstory shade is needed for regeneration success. The potential for forage production is also low, and there is little potential for increasing water yields. Potential for increasing big game winter range is low to moderate. The usual mixture of tree species and age classes provides good vertical diversity for birds. Any cutting in this habitat type should be directed toward maintaining diversity. Although the potential for increasing water yield is low, the habitat type provides watershed protection.

### *Pseudotsuga menziesii/Carex geyeri*

#### Description

The *Pseudotsuga menziesii/Carex geyeri* habitat type, represented by four stands, is a minor habitat in the *P. menziesii* series. It is only found west of the Continental Divide on the Arapaho National Forest, adjacent to Middle Park, on steep to very steep (45–80%) north- to northwest-facing slopes. The *P. menziesii/C. geyeri* habitat occupies an environment wetter than *P. menziesii/C. rossii* but drier than the other *P. menziesii*-dominated habitat types in the *P. menziesii* series. Soils are Alfisols (Mollic and Typic Cryoboralfs). They are moderately deep loams developed in place from conglomerate, sandstone, and shale parent materials (table 1). This topographic climax is recognized by a relatively closed canopy of self-reproducing *P. menziesii* and an undergrowth dominated by *C. geyeri* (26–42% coverage) (fig. 11). Widely scattered *Juniperus scopulorum* is the only tree associate. Important shrubs are *Pachistima myrsinites*, *Rosa woodsii*, and *Symphoricarpos oreophilus*. In addition to *C. geyeri*, *Poa* spp. and *Stipa columbiana* are important graminoids. The major forbs include *Anaphalis margaritacea*, *Astragalus flexuosus*, *Clematis occidentalis*, *Fragaria ovalis*, and *Galium boreale*.

Pfister et al. (1977) in Montana east of the Continental Divide, and Steele et al. (1981) in central Idaho reported a *P. menziesii/C. geyeri* habitat type; but the undergrowth

**Figure 11.—*Pseudotsuga menziesii/Carex geyeri* habitat type. *C. geyeri* forms moderate to dense undergrowth cover.**

differs widely in species composition. Komarkova[8] described a *P. menziesii/C. geyeri* habitat type in western Colorado that closely approximates the *P. menziesii/C. geyeri* habitat type reported here.

#### Management Implications

The potential for timber production is moderate to low, because the steep slopes restrict timber harvesting. If *P. menziesii* is harvested, cutting methods that maintain overstory shade and minimize soil disturbance are most appropriate. Regeneration of *P. menziesii* is likely to be difficult to obtain with any cutting method, especially where there is pressure from big game or where precipitation is below average. The potential for forage production for livestock is moderate, and moderate to high for big game winter range, mostly as hiding cover. Heavy livestock or big game use, or heavy mechanical seedbed preparation may deplete the *C. geyeri* sod. The potential for increasing water yield is lower than in subalpine forests.

### *Pseudotsuga menziesii/Physocarpus monogynus*

#### Description

The *Pseudotsuga menziesii/Physocarpus monogynus* habitat type, a topographic climax, represented by four stands, is the most common and widely distributed *P. menziesii* habitat type east of the Continental Divide. It is found on all districts of the Roosevelt National Forest in wetter environments than the *Carex*-dominated habitat types. This habitat type occurs on steep (55–65%) north- to northwest-facing slopes. Soils are mostly Alfisols (Typic Eutroboralfs and Typic Cryoboralfs). They are moderately deep, coarse colluvium derived from granite, gneiss, and schist (table 1). The habitat type is recognized by the overstory dominance of *P. menziesii* and the understory dominance (14–35% coverage) of the shrub *P. monogynus* (fig. 12). *Pinus ponderosa* and *Juniperus scopulorum* are seral tree species. Other important shrubs are *Jamesia americana*, *Juniperus communis*, and *Symphoricarpos albus*. The major graminoid is *Hesperochloa kingii*; primary forbs include *Achillea lanulosa*, *Galium boreale*, *Geranium fremontii*, and *Potentilla fissa*.

Hoffman and Alexander (1976) reported a *P. menziesii/P. monogynus* habitat type in the Bighorn Mountains of Wyoming. Moir and Ludwig (1979) also described a *P. menziesii/P. monogynus* habitat type in northern New Mexico. A *Pseudotsuga menziesii/Physocarpus malvaceus* habitat type, which has similar characteristics, has been reported in eastern Washington and northern Idaho (Cooper et al.,[9] Daubenmire and Daubenmire 1968), Montana (Pfister et al. 1977), central

[8]*Komarkova, Vera. Habitat types on selected parts of the Gunnison and Uncompahgre National Forests. (Final report.)*

[9]*Cooper, Steven, Kenneth Neiman, and Robert Steele. Forest habitat types of northern Idaho. (Manuscript in preparation.)*

and eastern Idaho and northwestern Wyoming (Steele et al. 1981, 1983), and in Utah (Mauk and Henderson 1984, Youngblood and Mauk 1985).

### Management Implications

This habitat type usually is the most productive in the *P. menziesii* series; but site indexes still may be relatively low. Where *P. ponderosa* is an important seral species, the *P. menziesii/P. monogynus* habitat type can be managed by cutting *P. menziesii* to release *P. ponderosa*. Otherwise, *P. menziesii* can be managed most successfully by the shelterwood and selection cutting methods that maintain overstory shade. Reproduction is likely to be difficult to obtain with any cutting method, however. Moreover, slopes may be too steep to harvest. Livestock forage production is low, and the potential for any increase is not great. Deer may use the shrub species heavily at times, and both deer and elk use the habitat type for thermal cover. The potential for increasing natural runoff is higher than in the *Pinus ponderosa* series, but much less than in the higher subalpine forests.

### *Pseudotsuga menziesii/Jamesia americana*

### Description

The *Pseudotsuga menziesii/Jamesia americana* habitat type, an edaphic climax, represented by four stands, has a broad geographical distribution on the Roosevelt National Forest but is not abundant in any one locality. The habitat type occurs on steep to very steep (55–75%) north- to northwest-facing slopes. Soils are Alfisols and Inceptisols (Typic Eutroboralfs, Typic Eutrochrepts, and Typic Cryocrepts). They are shallow, rocky, coarse-textured colluvium derived from gneiss, schist, and granite (table 1). Often, there are large boulders on the surface. It is recognized by the overstory dominance and reproductive success of *P. menziesii*, and the dominance of *J. americana* (17–29%) in the undergrowth (fig. 13). *Pinus ponderosa* and *Juniperus scopulorum* are seral overstory associates. In addition to *J. americana*, *Acer glabrum*, *Juniperus communis*, and *Physocarpus monogynus* are important shrubs. The herbaceous vegetation is dominated by *Fragaria ovalis*, *Potentilla fissa*, and *Saxifraga bronchialis*. The *P. menziesii/J. americana* habitat type has also been reported on the Gunnison National Forest in western Colorado by Komarkova[8].

**Figure 12.—*Pseudotsuga menziesii/Physocarpus monogynus* habitat type. Low growing *P. monogynus* dominates the understory in the foreground.**

**Figure 13.—*Pseudotsuga menziesii/Jamesia americana* habitat type. Steep slopes and large amounts of surface rock result in low timber potential for this habitat type.**

### Management Implications

Although this habitat type occurs in a wetter environment then the *Pseudotsuga menziesii/Physocarpus monogynus* habitat type, the potential for timber production is low. Moreover, steep slopes and large surface boulders preclude any harvesting of stands in the *P. menziesii/J. americana* habitat type with conventional methods. The potential for forage production for livestock is low. The potential for big game winter range as hiding cover is moderate; the shrubs are generally not used for browse. The potential for increasing streamflow is low because of the difficulty in harvesting stands and low precipitation.

## *POPULUS TREMULOIDES* SERIES

The *Populus tremuloides* series occurs throughout the montane and subalpine forest zones on the Arapaho and Roosevelt National Forests. It also occurs on the Dillon District in the southwestern part of the Arapaho National Forest, which is administered by the White River National Forest (Hess and Wasser[5]). The *P. tremuloides* series occupies a wide range of mesic environments on sites with a high water table with favorable topographic positions for moisture retention. Although *P. tremuloides* is found on both sides of the Continental Divide, it reaches its widest distribution in the study area in the northwestern part of the Arapaho National Forest and the northern Roosevelt National Forest at elevations of 8,040 to 9,680 feet (2,450 to 2,950 m) (table 1).

There has been considerable discussion regarding the role of *P. tremuloides* as a climax and/or seral species in the Rockies; both assessments may be correct (Mueggler 1985a). In some areas, *P. tremuloides* dominates sites where fires have destroyed coniferous forests. In time, conifers gradually replace *P. tremuloides*. Succession to coniferous forest apparently is slowed significantly by changes in soil resulting from site occupancy by the deciduous *Populus*. In other areas, *P. tremuloides* forests appear to be climax without evidence of conifer invasion. According to Mueggler (1985a), complete conversion of *Populus* stands to coniferous climax forest may require more than 1,000 fire-free years. The origin of both seral and climax *P. tremuloides*-dominated forests may be the same—destruction of coniferous forest by repeated fires.

Many *P. tremuloides* forests are even-aged (Jones and DeByle 1985); the trees originate from sprouts after a disturbance. In stands where older trees die naturally over a short time span, an even-aged replacement stand may develop (Mueggler 1985a). Other stands are uneven-aged, and sprouts apparently provide enough young trees to perpetuate the species indefinitely. Two-storied stands are also relatively common and can develop when surface fires burn quickly through mature stands without killing all trees, thereby stimulating sprouting.

The *P. tremuloides* series was sampled in 12 stands representing three habitat types. Basal areas ranged from 142 to 263 square feet per acre (33 to 60 $m^2/ha$). Tree sizes ranged from seedlings to the 16- to 20-inch (4- to 5-dm) d.b.h. class. Tree populations and undergrowth data for the *P. tremuloides* stands are shown in tables A–1 and A–5.

### *Populus tremuloides/Festuca thurberi*

#### Description

The *Populus tremuloides/Festuca thurberi* habitat type, represented by four stands, is the driest of the *P. tremuloides* habitat types. This minor habitat type is found on both sides of the Continental Divide but is more prevalent on the Arapaho National Forest, including the Dillon District. It is considerably more common in southern and western Colorado, where it often occurs adjacent to *Artemisia*-dominated shrublands. The *P. tremuloides/F. thurberi* habitat type is usually found on moderately steep (20–30%) south-facing slopes or depressions in ridges with concave surfaces suitable for snow accumulation. Soils are primarily Mollisols (Pachic Cryoborolls). They are moderately deep, loamy alluvium and colluvium derived from a wide variety of parent rocks (table 1).

The *P. tremuloides/F. thurberi* habitat type is recognized by the overstory dominance and reproductive success of *P. tremuloides* and the dominance of the undergrowth by *F. thurberi* (36–45% coverage) (fig. 14). Shrubs, weakly represented, are comprised of *Amelanchier alnifolia*, *Artemisia tridentata*, *Rosa woodsii*, and *Symphoricarpos oreophilus*. In addition to *F. thurberi*, other important graminoids are *Agropyron trachycaulum*, *Bromus anomalus*, *Carex geyeri*, *Poa interior*, and *Stipa columbiana*. Important forbs are *Achillea lanulosa*, *Erigeron speciosus*, *Lathyrus leucanthus*, and *Vicia americana*.

**Figure 14.—*Populus tremuloides/Festuca thurberi* habitat type. This habitat type frequently occurs in small stands surrounded by *F. thurberi* meadows and shrublands.**

Hess and Wasser[5] on the White River National Forest and Komarkova[8] on the Gunnison National Forest in western Colorado also described a *P. tremuloides/F. thurberi* habitat type. This habitat type has not been described elsewhere (Alexander 1985).

#### Management Implications

Timber productivity on this dry *P. tremuloides/F. thurberi* habitat type is moderate to low; growth is slow and trees are short, open-grown with poor form. Clearcutting usually is an effective way to regenerate a new *P. tremuloides* stand. However, it is somewhat risky in this habitat type, because stands are often small and adjacent to *F. thurberi* meadows; and the chance of converting these stands to *F. thurberi* is great when the *P. tremuloides* overstory is removed. Success in regenerating stands in this habitat type is enhanced by burning immediately after clearcutting. The potential for forage production is high on sites in good condition with a high cover of *F. thurberi*. Forage is more palatable to cattle than sheep; but these stands are not usually very important rangelands, because *F. thurberi* is only moderately palatable. This habitat type can be heavily used by big game in the late fall and winter for food and cover. Heavy winter use by big game animals can damage mature *P. tremuloides* stems and can eliminate all sprouts. Annual precipitation varies from 18 to 25 inches (46 to 64 cm), with about 9 to 12 inches (23 to 30 cm) of runoff; but potential for increasing streamflow is unknown. Erosion, sedimentation, and mass movement potentials are low. The *P. tremuloides/F. thurberi* usually has low visual potential. Color contrast is low because of the absence of conifers, and the low density of shrubs does not provide much texture or variety in seasonal color. However, isolated stands in grasslands or shrublands can be locally important where the interstand contrast is visible.

### *Populus tremuloides/Carex geyeri*

#### Description

The *Populus tremuloides/Carex geyeri* habitat type is widely distributed throughout the Arapaho and Roosevelt National Forests; but it is most conspicuous in the northern Roosevelt National Forest. This habitat type occurs on moderate to steep (15–60%) south-facing slopes. Soils are principally Mollisols (Typic, Argic, and Pachic Cryoborolls). They are moderately deep, loamy colluvium and alluvium derived primarily from sedimentary parent materials (table 1).

The *P. tremuloides/C. geyeri* habitat type, represented by four stands, is recognized by the dominance of *P. tremuloides* in the overstory and *C. geyeri* (28–42% coverage) in the undergrowth (fig. 15). The undergrowth is relatively sparse for a *P. tremuloides*-dominated habitat type. Other tree associates are inconspicuous. Important shrubs include *Berberis repens*, *Juniperus communis*, and *Rosa woodsii*. Herbaceous understory species most conspicuous are *Bromus anomalus*, *B. marginatus*, *Carex geyeri*, *Elymus glaucus*, *Achillea lanulosa*, *Arnica cordifolia*, *Galium boreale*, and *Ligusticum porteri*.

This habitat type has been identified by Hoffman and Alexander (1983) on the White River National Forest in Colorado, and by Alexander et al.[4] on the Medicine Bow National Forest in Wyoming. Mauk and Henderson (1984) identified a similar vegetation association in the Uinta Mountains in Utah as *P. tremuloides/C. geyeri* community type.

#### Management Implications

Timber productivity on this dry habitat type is average to below average. Clearcutting and regenerating a new stand usually is the most effective way to perpetuate these stands. This habitat type is fair summer-fall range for big game and cattle. Forage production varies from 400 to 800 pounds per acre, dry weight (450 to 900 kg/ha), depending upon range condition and management practices; this can increase to 1,800 pounds per acre (2,000 kg/ha) for the first few years following clearcutting. Overgrazing may reduce *Carex* cover and expose soils that are difficult to revegetate. Annual precipitation varies from 20 to 30 inches (51 to 76 cm) with about 10 to 15 inches (25 to 38 m) of runoff. Potential for increasing streamflow is unknown. Erosion, sedimentation, and mass movement potentials are low. This habitat type has fair scenic quality, with less favorable color contrast than with mixed *Populus*-conifer stands. In open stands, the shrub understory provides both texture and variety in seasonal color. It also provides a pleasing ground color contrast in the fall, when *Carex* remains green after other undergrowth vegetation has withered and dried.

**Figure 15.—*Populus tremuloides/Carex geyeri* habitat type. *Vicia americana* partially obscures the dense undergrowth of *C. geyeri*.**

### *Populus tremuloides/Thalictrum fendleri*

#### Description

This habitat type, represented by four stands, is found in the wettest environments associated with the *Populus tremuloides* series. The *P. tremuloides/T. fendleri* habitat is a minor habitat type throughout the Arapaho and Roosevelt National Forests, but is locally abundant in the far northern Roosevelt National Forest and the northwestern Arapaho National Forest. It also is found in the southwestern Arapaho National Forest, on the Dillon District. The habitat type occurs on gentle to moderate (5–40%) slopes with variable aspects. Soils are mostly Mollisols (Argic Pachic Cryoborolls). They are deep, fine-textured, moderately well-drained alluvium and colluvium of sedimentary origin (table 1).

The *P. tremuloides/T. fendleri* habitat type is recognized by the constant reproductive success of *P. tremuloides* and the high coverage (21–28%) of *T. fendleri* and *Ligusticum porteri* (7–52% coverage) in the undergrowth (fig. 16). *P. tremuloides* is the only tree species present in two stands. In the other two stands, scattered *Abies lasiocarpa*, *Pinus contorta*, and *Pinus flexilis* occurred; but there is no evidence that these stands were moving toward a climax dominated by conifers.

Except for a few *Juniperus communis*, shrubs were absent in the stands sampled. Significant graminoids include *Agropyron trachycaulum*, *Bromus anomalus*, *B. marginatus*, *Carex geyeri*, and *Elymus glaucus*. In addition to *T. fendleri* and *L. porteri*, important forbs are *Aquilegia caerulea*, *Galium boreale*, *Geranium richardsonii*, *Osmorhiza depauperata*, and *Smilacina stellata*.

In Colorado, a *P. tremuloides/T. fendleri* habitat type has been reported on the White River National Forest by Hoffman and Alexander (1983) and Hess and Wasser,[5] on the Routt National Forest by Hoffman and Alexander (1980), and on the Gunnison National Forest by Komarkova.[8] This habitat type also occurs on the Medicine Bow National Forest in southeastern Wyoming (Alexander et al.[4]). Mueggler and Campbell (1982) and Youngblood and Mueggler (1981) described a similar community type in southeastern Idaho and western Wyoming.

## Management Implications

The *Populus tremuloides/Thalictrum fendleri* habitat type is the most productive for timber and forage in the *Populus* series. Site quality ranges from average to high. Clearcutting in patches or small blocks and regenerating new stands is the most effective way to handle these stands. This habitat type is the best *Populus*-dominated habitat type for summer range for big game and for sheep. Although forage production under proper grazing management can be as high as 3,000 pounds per acre (3,360 kg/ha) for the first few years after clearcutting, sustained production under a *Populus* overstory is closer to 1,500 pounds per acre (1,680 kg/ha).

This is the "classic" *Populus*-forb rangeland type that provides a significant amount of the forage produced on western ranges. Heavy livestock use, especially sheep, can reduce the cover of forbs. It also provides habitat for numerous nongame animals; but the management implications for them are unknown. This habitat type has the most visually appealing foreground of all *Populus*-dominated habitat types because of the usually wide spacing with large tree diameters and the abundance of wildflowers in the undergrowth. Soils are well developed, and erosion is usually not a problem, except on deteriorated ranges. In some situations, potential for soil mass movement appears to be high, especially if the overstory is removed in large clearcut blocks. Annual precipitation is 25 to 40 inches (64 to 102 cm), with about one-half becoming runoff. Potential for increasing streamflow under management is unknown.

## *PINUS FLEXILIS* SERIES

The *Pinus flexilis* series occurs along a broad elevational gradient, delineated by very narrow environmental parameters. The habitat types of this series are confined to very rocky, windswept locations in the montane and subalpine zones of the Arapaho and Roosevelt National Forests at elevations ranging from 8,450 to 11,450 feet (2,575 to 3,490 m) (table 1).

**Figure 16.—*Populus tremuloides/Thalictrum fendleri* habitat type. Both *T. fendleri* and *Ligusticum porteri* provide a dense undergrowth.**

**Figure 17.—*Pinus flexilis/Juniperus communis* habitat type. It typically occurs on sites more exposed and xeric than surrounding montane forests.**

The *P. flexilis* series is represented by 12 plots and 3 habitat types. Basal areas ranged from 57 to 245 square feet per acre (13 to 56 m²/ha). Tree sizes ranged from seedlings to the 20- to 24-inch (5- to 6-dm) d.b.h. class. Tree population and undergrowth data for *Pinus flexilis* stands are shown in tables A–1 and A–6.

### *Pinus flexilis/Juniperus communis*

#### Description

*Pinus flexilis/Juniperus communis* is a minor but conspicuous habitat type found throughout the Arapaho and Roosevelt National Forests. This habitat type commonly occurs on exposed convex ridgetops and upper slopes on moderate (15–40%) slopes, often with rock outcroppings apparent within the stand. Soils are Entisols (Typic Cryorthents). They are shallow, coarse-textured, mostly developed in place from igneous and metamorphic parent material (table 1).

The *P. flexilis/J. communis* habitat type, represented by four plots, is recognized by the open tree canopy dominated by *P. flexilis*. *Pinus ponderosa* at lower elevations, and *Pinus contorta* at higher elevations, are common associates but neither shows evidence of replacing *P. flexilis*. The understory is dominated by *J. communis* (7–25% coverage) (fig. 17). The only other shrub species of high constancy is *Arctostaphylos uva-ursi*. Important herbaceous species include *Calamagrostis purpurascens*, *Carex rossii*, *Arenaria fendleri*, *Erigeron compositus*, *Geranium fremontii*, *Penstemon virens*, *Potentilla fissa*, and *Sedum stenopetalum*.

A *Pinus flexilis/Juniperus communis* habitat type was reported by Hoffman and Alexander (1980) on the Routt National Forest in northwestern Colorado, and by Alexander et al.[4] on the Medicine Bow National Forest in southeastern Wyoming. Their stands were at higher elevations; but some floristic similarities are evident. Hoffman and Alexander (1976, 1983) did not report a *P. flexilis/J. communis* habitat type in either the Bighorn Mountains of north-central Wyoming or on the White

River National Forest in western Colorado. Further north, Pfister et al. (1977) in Montana east of the Continental Divide and Steele et al. (1983) in northwestern Wyoming described a *Pinus flexilis/Juniperus communis* habitat type. *P. flexilis/J. communis* stands on the Arapaho and Roosevelt National Forests show little floristic similarity to those in Montana and northwestern Wyoming.

### Management Implications

This dry habitat type has very low productivity for timber production. Forage value for livestock and big game is low to moderate, with some evidence of use by mule deer in the spring and fall. Overstory trees adjacent to grasslands may provide cover for wildlife. The rocky ridges with sparse tree canopy can be important transitional range for bighorn sheep. *P. flexilis* seeds are large and are food for birds and small mammals. High surface temperatures and low soil moisture may impede regeneration or revegetation of disturbed areas. There is little or no potential for increasing streamflow; but the habitat type provides watershed protection.

## *Pinus flexilis/Calamagrostis purpurascens*

### Description

This habitat type is widely distributed on the Arapaho and Roosevelt National Forests, but is locally abundant only along the Front Range of Colorado. It is found on exposed rocky convex ridgetops and upper slopes on moderate slopes (10–35%) with variable aspects. Soils are Entisols (Typic Cryorthents). They are shallow, coarse-textured, developed in place from gneiss, schist, and granite (table 1).

The *P. flexilis/C. purpurascens* habitat type, represented by four stands, is recognized by the dominance of open-grown *P. flexilis* in the overstory and *C. purpurascens* (9–20% coverage) in the undergrowth (fig. 18). Isolated

**Figure 18.—*Pinus flexilis/Calamagrostis purpurascens* habitat type. *P. flexilis* is typically open-grown with a highly visible undergrowth of *C. purpurascens*.**

*Picea engelmannii* and *Pinus contorta* occur in the overstory, but show no reproductive success. The shrub layer is depauperate and absent in many stands. Important graminoids are *C. purpurascens*, *Carex rossii*, and *Poa rupicola*. The primary forbs include *Arenaria fendleri*, *Erigeron pinnatisectus*, *Potentilla pulcherrima*, *Pulsatilla ludoviciana*, and *Sedum stenopetalum*. This habitat type has not been reported elsewhere.

### Management Implications

The potential for timber production and fuelwood in the *P. flexilis/C. purpurascens* habitat type is very low; growth is extremely slow. Forage potential for livestock and big game also is low. The establishment of trees and other vegetation after disturbance is very slow and difficult. These rocky ridges with open tree canopies can be important transitional range for bighorn sheep. *P. flexilis* seeds are food for birds and small mammals, and the trees provide cover for wildlife. There is little or no potential for increasing streamflow; but this habitat type provides watershed protection.

## *Pinus flexilis/Trifolium dasyphyllum*

### Description

The *Pinus flexilis/Trifolium dasyphyllum* habitat type occurs at or just below timberline throughout the Arapaho and Roosevelt National Forests. It is found on moderately steep (30–55%) south-facing slopes at the interface between subalpine forests and alpine tundra. This topographic position results in a harsh and xeric environment. Soils are Entisols (Typic Cryorthents). They are very shallow, rocky, and coarse-textured, developed in place from granitic rock (table 1).

This habitat type, represented by four stands, is dominated by a moderately closed canopy of *P. flexilis*. *Abies lasiocarpa* and *Picea engelmannii* are minor overstory associates. The undergrowth is dominated by *T. dasyphyllum* (20–44% coverage) (fig. 19). *Juniperus communis* and *Potentilla fruticosa* are the important shrubs. In addition to *T. dasyphyllum*, other herbaceous undergrowth includes *Calamagrostis purpurascens*, *Carex foenea*, *Festuca brachyphylla*, *Poa* spp., *Achillea lanulosa*, *Antennaria parviflora*, *Arenaria fendleri*, *Campanula rotundifolia*, *Mertensia viridis*, and *Solidago ciliosa*. The *P. flexilis/T. dasyphyllum* has not been reported elsewhere.

### Management Implications

The potential for timber and forage production is very low. Recovery from disturbance is very slow, because tree growth is very slow. The visual potential is high, because *P. flexilis/T. dasyphyllum* forests form a prominent interface between the forested subalpine zone and the treeless alpine zone. This habitat type is important for animals, such as elk, that seek cover at timberline during the summer. The *P. flexilis/T. dasyphyllum* habitat type provides watershed protection; but there is little or no potential for increasing streamflow.

## *PINUS CONTORTA* SERIES

The *Pinus contorta* series is a major forest type throughout the Arapaho and Roosevelt National Forests in the upper montane and lower subalpine zones, at elevations of 8,400 to 10,500 feet (2,560 to 3,200 m) (table 1). *Pinus contorta*'s occurrence in the Arapaho and Roosevelt National Forests and elsewhere in the Rocky Mountains usually is attributed to widespread and repeated fires. There is less agreement on its successional status. Many ecologists and foresters consider *P. contorta* a seral species, which, in the absence of fire, would be replaced by forests dominated by *Picea engelmannii* and *Abies lasiocarpa* at higher elevations, and *Pseudotsuga menziesii* and *Pinus ponderosa* at lower elevations (Clements 1910, Daubenmire 1943, Mason 1915).

More recently, investigators have concluded that *Pinus contorta* is climax, or at least a long-lived subclimax, species in certain topo-edaphic situations, especially on cold sites with thin, excessively-drained soils. Moir (1969) reported it to be climax within the upper montane zone of the Front Range of Colorado. Hoffman and Alexander (1976, 1980), and Alexander et al.[4] described climax *P. contorta* forests in the Bighorn Mountains, Wyoming, occurring on soils derived from granites, on the Medicine Bow National Forest and on the Routt National Forest. Hess and Wasser[5] and Komarkova[8] also described climax *P. contorta* stands on the White River and Gunnison National Forests, respectively. Climax *P. contorta* forests are described in the Wind River and Absaroka Mountains, western Wyoming, by Steele et al. (1983). Pfister et al. (1977) and Steele et al. (1981) reported apparently stable and climax *Pinus contorta* forests in Montana and in Idaho. Mauk and Henderson (1984) also described climax *P. contorta* forests in northern Utah.

In the Arapaho and Roosevelt National Forests, *P. contorta* was rarely encountered in *Pseudotsuga menziesii* and *Populus tremuloides* forests; but it was a common seral species in *Picea engelmannii-Abies lasiocarpa* forests. Seral *P. contorta* is more likely to be even-aged and bear a high proportion of serotinous cones. Where *P. contorta* is the dominant self-reproducing species, it may exhibit a population structure of several age classes, and has no competition from its common associates. Climax *P. contorta* stands are more likely to contain a higher proportion of trees bearing nonserotinous cones.

In some areas, especially on dry poor sites, *P. contorta* forms dense dog-hair stands with little undergrowth. In these situations, *P. contorta* may be a seral species that will occupy the site for hundreds of years, simply because there is no seed source of climax species available for reinvasion.

This series is represented by 17 stands and 4 habitat types. Basal areas ranged from 109 to 245 square feet per acre (25 to 56 $m^2$/ha). Tree sizes ranged from seedlings to the 16- to 20-inch (4- to 5-dm) d.b.h. class. Tree population and undergrowth data for *Pinus contorta* stands are shown in tables A–1 and A–7.

**Figure 19.—*Pinus flexilis/Trifolium dasyphyllum* habitat type. *P. flexilis* in this habitat type frequently grow in denser stands and have fuller crowns than in other *P. flexilis* habitat types.**

### ***Pinus contorta/Juniperus communis***

#### Description

This habitat type, represented by four stands, is the driest of the *Pinus contorta* series. It is most commonly found on the Roosevelt National Forest east of the continental Divide on gentle to moderate slopes (10–45%) with variable aspects. However, the *Pinus contorta/Juniperus communis* habitat type attains its highest elevational extension on south-facing slopes and its lowest elevational extension on north-facing slopes. Soils are Alfisols (mixed Cryoboralfs). They are moderately deep, medium-textured loams derived from a variety of parent materials (table 1).

This habitat type is recognized by the dominance and reproductive success of *P. contorta* in the overstory and the dominance of *J. communis* (9–15% coverage) in the undergrowth (fig. 20). *Pseudotsuga menziesii* and *Picea engelmannii* occur occasionally; but there is no evidence of replacement of *P. contorta*. Important shrubs are *J. communis, Arctostaphylos uva-ursi, Berberis repens*, and *Rosa woodsii*. Herbaceous vegetation is scarce with *Arnica cordifolia, Penstemon virens, Potentilla fissa*, and *Sedum stenopetalum* the only species occurring with high consistency.

In Colorado, Komarkova[8] described a *P. contorta/J. communis* habitat type on the Gunnison National Forest. This habitat type also occurs on the Medicine Bow National Forest in southeastern Wyoming (Alexander et al.[4]). In northwestern Wyoming and southwestern Idaho, Steele et al. (1983), and in northern Utah, Mauk and Henderson (1984) reported a *P. contorta/J. communis* community type that is similar to the habitat type described above, except that its successional status is unclear. A similar habitat type was not described on the Routt National Forest (Hoffman and Alexander 1980) or the, White River National Forest (Hoffman and Alexander 1983).

## Management Implications

The *Pinus contorta/Juniperus communis* habitat type has the lowest timber production potential of the *P. contorta* series. Regeneration is likely to be difficult to obtain in this dry habitat type. Clearcutting or shelterwood cutting can be used in sawlog-sized stands regardless of cone habit. Scarification is likely to be essential for natural regeneration success. On south slopes and in tension zones, a long regeneration period usually follows clearcutting because of limited soil moisture. In those situations, a shelterwood system is more likely to result in regeneration success; but a shelterwood should not be used in dwarf mistletoe infected stands. On other aspects, clearcutting is usually successful, but can result in either too much or too little reproduction, depending on the cone habit, amount of seed available, and slash disposal treatment (Alexander 1986b).

If a clearcut option is used in stands with nonserotinous cones, openings should be in the form of small [3- to 5-acre (1- to 2-ha)] patches or narrow [400-foot wide (122-m)] strips where natural regeneration is desired. Large-clearcut openings will require fill-in planting. In stands with serotinous cones, clearcut openings up to 40 acres (16 ha) may be used if the stand is heavily infected with dwarf mistletoe. Care must be used in slash disposal in these stands so that the seed source is not destroyed. Group selection cutting is a possibility in stands with irregular structure; but individual-tree selection cutting is generally appropriate only in recreation areas.

In young *P. contorta* pole stands, thinning is needed to reduce basal area and improve soil moisture conditions. Growing stock levels (GSL) of 80 to 120 are most appropriate for timber production (Alexander and Edminster 1981). Forage production usually is increased for a short time following clearcutting; but the potential for increasing forage production for either livestock or big game is limited in this habitat type. Natural runoff in the *P. contorta/J. communis* habitat type is at least 8 inches (20 cm) annually. Much of the precipitation falls as snow. Streamflow can be increased by clearcutting in small patches.

**Figure 20.—*Pinus contorta/Juniperus communis* habitat type. Several age classes of *P. contorta* are apparent in this stand. There is no evidence of *Picea engelmannii* or *Abies lasiocarpa* regeneration.**

### *Pinus contorta/Carex geyeri*

## Description

The *Pinus contorta/Carex geyeri* habitat type occurs at the lowest elevations in the *Pinus contorta* series but occupies a wetter environment than the *P. contorta/Juniperus communis* habitat type. This habitat type is most commonly found west of the Continental Divide on the Arapaho National Forest, especially in the southwestern part, which is the Dillon District. East of the Continental Divide, it is found only along the Laramie River in the northern Roosevelt National Forest. The *P. contorta/C. geyeri* habitat type occurs on level to gentle (0–10%) north-facing slopes. Soils are Alfisols (Typic Cryoboralfs). They are moderately deep loams developed in place, primarily from sedimentary parent materials (table 1).

This habitat type, represented by four stands, is recognized by the overstory dominance and reproductive success of *Pinus contorta*, and the undergrowth dominance of *Carex geyeri* (22–41% coverage) (fig. 21). The shrub layer is poorly developed, with *Berberis repens*, *Juniperus communis*, and *Rosa woodsii*, the only species with high constancy. Herbaceous vegetation dominates the undergrowth. In addition to *C. geyeri*, other important graminoids are *Bromus anomalus*, *Poa interior*, and *Trisetum spicatum*. Important forbs include *Achillea lanulosa*, *Arnica cordifolia*, *Campanula rotundifolia*, and *Lathyrus leucanthus*.

In Colorado, a *Pinus contorta/Carex geyeri* habitat type has been reported on the White River National Forest by Hess and Wasser[5] and on the Gunnison National Forest by Komarkova.[8] Alexander et al.[4] reported a *P. contorta/C. geyeri* habitat type on the Medicine Bow National Forest in southeastern Wyoming. However, Hoffman and Alexander (1976, 1980, 1983) did not identify this habitat type on either the Routt National Forest or the White River National Forest in Colorado, or in the Bighorn Mountains of north-central Wyoming. Farther north, Steele et al. (1981, 1983) reported a *P. contorta/C. geyeri* community type in northwestern Wyoming and central Idaho that has similar characteristics, although there are differences in floristic composition.

## Management Implications

Timber productivity in this habitat type is average to below average. Site indexes are likely to be below average (Alexander 1966). Even-aged management, under either a clearcutting or shelterwood alternative, is recommended for most stands (Alexander 1986b). However, natural regeneration is difficult to obtain after clearcutting, because the *C. geyeri* dominated undergrowth competes severely with seedlings. A shelterwood cutting alternative has the advantage of better control over undergrowth development and may better meet wildlife cover and visual requirements. Although most stands in the *P. contorta/C. geyeri* habitat type bear serotinous cones, clearcutting in large openings is not recommended because of the competition between tree seedlings and *C. geyeri*. A better option would be to use the opening size recommended for stands with nonserotinous cones. Large openings have an advantage of reducing losses in stands infected with dwarf mistletoe or susceptible to attack by mountain pine beetle; but the manager must accept the likelihood that it will take a long time to regenerate these stands. Care must be used in slash disposal and seedbed preparation so that the seed source is not destroyed.

Uneven-aged management under individual-tree or group selection cutting can reduce stand susceptibility to mountain pine beetles by removing the most susceptible host trees. Group selection cutting is a possibility in stands with irregular structure; but individual-tree selection in stands not attacked by mountain pine beetles generally is appropriate only in recreation areas. Growth will be substantially reduced, however, with either uneven-aged cutting method.

In young *P. contorta* pole stands, thinning is needed to reduce basal area and improve soil moisture conditions. Growing stock levels of 100 to 120 are most appropriate for timber production (Alexander and Edminster 1981). Forage production is fair to poor and not likely to be improved by cutting. Wildlife habitat is poor, and the potential for increasing it is not very good. Big game use is limited, and nongame bird and small mammal populations are sparse.

Natural runoff in the *P. contorta/C. geyeri* habitat type is at least 10 inches (25 cm) annually. Much of the precipitation falls as snow. Streamflow can be increased by clearcutting in small 3- to 5-acre patches (Leaf 1975, Leaf and Alexander 1975). If larger openings are used, slash should be left in place to increase surface roughness. Streamflow can also be increased by partial cutting on north aspects; but it will be less than with clearcutting (Troendle and Meiman 1984).

**Figure 21.—*Pinus contorta/Carex geyeri* habitat type. Stands of this habitat type are common west of the Continental Divide. *C. geyeri* forms a dense undergrowth.**

**Figure 22.—*Pinus contorta/Shepherdia canadensis* habitat type. Several age classes of *P. contorta* are apparent. *Picea engelmannii* and *Abies lasiocarpa* regeneration are absent.**

### *Pinus contorta/Shepherdia canadensis*

#### Description

*Pinus contorta/Shepherdia canadensis* is a major habitat type on the Arapaho National Forest, including the Dillon District, and along the Laramie River in northern Roosevelt National Forest. This habitat type occurs on gentle to moderate (10–40%) slopes with variable aspects. *P. contorta/S. canadensis* occurs in close proximity to the *Pinus contorta/Carex geyeri* habitat type, but on steeper, more rocky and drier sites. Soils are Alfisols (Typic Cryoboralfs). They are moderately deep loams, mainly alluvial and colluvial, derived from volcanic and sedimentary parent materials (table 1).

In the five stands sampled, the constant presence and reproductive success of *P. contorta*, the absence of any significant reproduction of other tree species, and the understory dominance of *S. canadensis* (31–47% coverage) are the diagnostic features of this habitat type (fig. 22). In addition to *S. canadensis*, important shrubs are *Arctostaphylos uva-ursi, Berberis repens, Juniperus communis*, and *Vaccinium scoparium*. Important herbaceous species include *Carex geyeri* and *Carex rossii* among the graminoids, and *Arnica cordifolia, Epilobium angustifolium, Haplopappus parryi*, and *Pyrola chlorantha* among the forbs.

Hoffman and Alexander (1980) on the Routt National Forest, and Hess and Wasser[5] on the White River National Forest, reported a *P. contorta/S. canadensis* habitat type, which closely resembles the habitat type described here. This habitat type also occurs on the Medicine Bow National Forest in southeastern Wyoming (Alexander et al.[4]). However, Hoffman and Alexander (1983) did not report a *P. contorta/S. canadensis* habitat type on the White River National Forest, nor was a similar habitat type observed on the Gunnison National Forest (Komarkova[8]). Further north, Hoffman and Alexander (1976) described an *Abies lasiocarpa/S. canadensis* habitat type on north slopes in the Bighorn Mountains, which was characterized by the presence of *V. scoparium* beneath the *S. canadensis*-dominated undergrowth.

Steele et al. (1983) reported a *P. contorta/Shepherdia canadensis* community type in southeastern Idaho and northwestern Wyoming.

## Management Implications

The *Pinus contorta/Shepherdia canadensis* habitat type is reasonably productive for timber, even though site indexes are likely to be average to below average (Alexander 1966). Even-aged management, under either a clearcutting or shelterwood cutting alternative, is recommended for most stands (Alexander 1986b). A shelterwood system has the advantages of better meeting wildlife cover and visual management requirements while at the same time providing shade needed to conserve soil moisture and help control overstocking. It also provides some control over dwarf mistletoe, although clearcutting is a more effective silvicultural control. Clearcutting can result in either too much or too little reproduction, depending on the cone habit, amount of seed available, and slash disposal treatments (Alexander 1974).

If a clearcut option is used in stands with nonserotinous cones, openings should be in the form of 3- to 5-acre (1- to 2-ha) patches or narrow 400-foot (122-m) wide strips where natural regeneration is desired. Large clearcut openings will require fill-in planting. In stands with serotinous cones, clearcut openings up to 40 acres (16 ha) may be used if the stand is heavily infected with dwarf mistletoe or infested with mountain pine beetles. Care must be used in slash disposal in these stands so that the seed source is not destroyed.

Uneven-aged management under individual-tree or group selection cutting can reduce stand susceptibility to mountain pine beetles by removing the most susceptible host trees. Group selection cutting is a possibility in stands with irregular structure; but individual-tree selection in stands not attacked by mountain pine beetles generally is appropriate only in recreation areas. Growth will be substantially reduced, however, with either uneven-aged cutting method.

In young *P. contorta* pole stands, thinning is needed to reduce basal area and improve soil moisture conditions. Growing stock levels of 120 to 160 are most appropriate for timber production (Alexander and Edminster 1981). Forage production usually is increased for a short time after clearcutting; but the potential for increasing forage production for either livestock or browse for big game is limited in this habitat type. Mule deer or elk may use these stands for hiding cover in winter, mostly because of their location adjacent to bottomlands or *Artemisia*-dominated shrublands.

Natural runoff in the *P. contorta/Shepherdia canadensis* habitat type is 10 to 12 inches (25 to 30 dm) annually. Much of the precipitation falls as snow. Streamflow can be substantially increased by clearcutting about one-third of the area in small patches interspersed with uncut timber (Leaf 1975, Leaf and Alexander 1975). If larger openings are cut, slash should be left in place to create surface roughness needed to retain the snowpack. Streamflow also can be increased by partial cutting on north slopes; but runoff will be less than with clearcutting (Troendle and Meiman 1984).

**Figure 23.—*Pinus contorta/Vaccinium scoparium* habitat type. The xeric environment and shallow soils of this habitat type contrast sharply with surrounding *A. lasiocarpa* habitat types.**

## *Pinus contorta/Vaccinium scoparium*

### Description

This habitat type extends to the upper attitudinal limits of the *P. contorta* series. It occurs on both the Arapaho and Roosevelt National Forests, but is more prevalent east of the Continental Divide. The *P. contorta/V. scoparium* habitat type occupies moderate to steep (15–45%) cold, dry south-facing slopes. Soils are Entisols (Typic Cryorthents). They are usually shallow, well-drained, gravelly loams developed in place largely from granitic rock (table 1).

This habitat type, represented by four plots, is recognized by overstory dominance and reproductive success of *P. contorta*. The occasional presence of *Abies lasiocarpa* and *Picea engelmannii* are not sufficient to indicate replacement. The depauperate undergrowth is dominated by *Vaccinium scoparium* (30–47% coverage) (fig. 23). Associated shrubs of high constancy are *Juniperus communis* and *Rosa woodsii*. Herbaceous vegetation, inconspicuous and poorly represented, includes *Carex geyeri*, *Arnica cordifolia*, *Epilobium angustifolium*, *Lupinus argenteus*, and *Solidago ciliosa*.

A *P. contorta/V. scoparium* habitat type was reported in the Bighorn Mountains by Hoffman and Alexander (1976), on the Gunnison National Forest by Komarkova,[8] and on the Medicine Bow National Forest in southeastern Wyoming by Alexander et al.[4] However, no similar habitat type was observed by Hoffman and Alexander (1980, 1983) on the Routt or on the White River National Forests in Colorado. A similar community type was reported in Montana by Pfister et al. (1977), in central Idaho by Steele et al. (1981), in northwestern Wyoming by Steele et al. (1983), in northern Idaho by Cooper et al.,[9] and in the Uinta Mountains of Utah, by Mauk and Henderson (1984).

### Management Implications

Site indexes and timber productivity are the highest in the *P. contorta* series. Even-aged management under either a clearcutting or shelterwood cutting alternative is recommended for most stands (Alexander 1986b). A shelterwood system has the advantages of meeting wildlife cover and visual management requirements while at the same time providing shade needed to conserve soil moisture and control overstocking. It also provides some control over dwarf mistletoe, although clearcutting is a more effective silvicultural control. Uneven-aged management under individual-tree or group selection cutting can reduce stand susceptibility to mountain pine beetles by removing the most susceptible host trees. Growth will be substantially reduced, however. Treatment of stands in relation to cone serotiny is the same as in the *P. contorta/Shepherdia canadensis* habitat type.

Poletimber stands in this habitat type have better spacing and crown class differentiation. Thinning to growing stock levels of 120 to 160 is most appropriate for individual tree and stand growth (Alexander and Edminster 1981).

The *P. contorta/V. scoparium* habitat type is fair summer range for wildlife. Forage production is the best in the *P. contorta* series for big game summer range and can increase substantially for short periods of time following clearcutting. Forage production for livestock can be increased by clearcutting to 500 pounds per acre (560 kg/ha), providing there is a good response by herbaceous vegetation. Natural runoff in the *P. contorta/V. scoparium* habitat type is 12 to 15 inches (30 to 38 cm). Management to increase water yield is the same as for the *P. contorta/Shepherdia canadensis* habitat type.

## *PICEA ENGELMANNII* SERIES

The *Picea engelmannii* series represents a minor forest type; but it occurs throughout the Arapaho and Roosevelt National Forests. This series is confined to a narrow upper subalpine zone at elevations of 10,820 to 11,320 feet (3,300 to 3,450 m), immediately below the *Picea engelmannii/Salix pseudolapponum* Krummholz and above or intermixed with the *Abies lasiocarpa* series (table 1). The *P. engelmannii* series is recognized by the absence or weak representation of *A. lasiocarpa* in the stands.

This series is represented by four plots and one habitat type. Basal areas range from 188 to 246 square feet per acre (43 to 56 m$^2$/ha). Tree sizes ranged from seedlings to the 16- to 20-inch (4- to 5-dm) d.b.h. class. Tree population and undergrowth data for *Picea engelmannii* are shown in tables A-1 and A-8.

### *Picea engelmannii/Trifolium dasyphyllum*

### Description

This minor habitat type, found at high elevations, is the only *Picea engelmannii*-dominated forest habitat type

**Figure 24.—*Picea engelmannii/Trifolium dasyphyllum* habitat type. Herbaceous undergrowth in this habitat type is typically sparse.**

on the Arapaho and Roosevelt National Forests.[10] It occurs on moderately steep (20–45%) north-facing slopes that are mostly convex to undulating. Soils are Entisols (Typic Cryorthents). They are shallow, coarse-textured colluvium developed from mostly granitic parent material (table 1).

This habitat type is recognized by the exclusive overstory dominance and reproductive success of *Picea engelmannii* and the understory dominance of *Trifolium dasyphyllum* and *T. parryi* (fig. 24). *Abies lasiocarpa* and *Pinus aristata* are minor components of the overstory. The shrub layer is virtually nonexistent; herbaceous species, primarily *T. dasyphyllum* (3–10% coverage) and *T. parryi* (1–8% coverage), dominate the undergrowth. Other important herbaceous species are *Festuca brachyphylla*, *Trisetum spicatum*, *Arenaria fendleri*, *Penstemon whippleanus*, *Pryola minor*, and *Sedum stenopetalum*. The *P. engelmannii/T. dasyphyllum* habitat type has not been reported elsewhere (Alexander 1985).

### Management Implications

The potential for timber production and the site indexes of this habitat type are very low. Regeneration of *Picea engelmannii* is difficult to obtain if stands are clearcut, burned, or otherwise disturbed. Natural succession is so slow that disturbance often results in type conversion. Because this habitat type occurs on cold, exposed sites, partial cutting is likely to result in severe windthrow to the residual stand. Stands in this habitat type are highly visible, and any modification of existing stands should consider the visual aspects.

The *P. engelmannii/T. dasyphyllum* habitat type provides food and cover for many small mammals and nongame birds. Hiding cover provided by this habitat is an important part of mule deer and elk summer range. Production of forage for big game and livestock is low, however. Natural runoff from snowpack exceeds 15

[10]*Hess (1981) identified a Picea engelmannii/Salix pseudolapponum habitat type on the Arapaho and Roosevelt National Forests. It is omitted from this paper because it is Krummholz, not a forest habitat type.*

inches (38 cm), and watershed protection values are high. The potential for increasing water yields are not very good, however, because of the difficulties of regenerating new stands after clearcutting; and the high windrisk makes partial cutting hazardous.

## *ABIES LASIOCARPA* SERIES

The *Abies lasiocarpa* series is a major forest type throughout the Arapaho and Roosevelt National Forests. It occupies the highest and coldest coniferous forest zone on the Arapaho and Roosevelt National Forests (table 1). These forests—dominated by *Abies lasiocarpa* and *Picea engelmannii*—are usually referred to as the subalpine forest zone. As throughout much of the Rocky Mountains, the subalpine forest zone is widespread and supports forests of considerable importance. On the Arapaho and Roosevelt National Forests, it is found on all aspects at elevations ranging from 9,020 to 11,320 feet (2,750 to 3,450 m), a span of 2,300 feet (755 m). It has been reported as low as 8,000 feet (2,440 m) to as high as 11,500 feet (3,500 m) in the central Rocky Mountains. On the Arapaho and Roosevelt National Forests, the lower elevational limits of *Abies lasiocarpa*-dominated forests and the upper elevational limits of the *Pinus contorta*-dominated forests overlap, although aspect and soils play some part in the forest distribution.

The habitat types described in this series are all named for *Abies lasiocarpa* as the climax dominant to be consistent with usage elsewhere (Daubenmire and Daubenmire 1968; Hoffman and Alexander 1976, 1980, 1983; Mauk and Henderson 1984; Pfister et al. 1977; Steele et al. 1981, 1983; Alexander et al.[4]). On the Arapaho and Roosevelt National Forests, *Picea engelmannii* is a coclimax dominant with little evidence that it will ever be completely replaced by *Abies lasiocarpa*. Young *Abies lasiocarpa* usually outnumber the young *Picea engelmannii* because *Abies lasiocarpa* is more tolerant and reproduces by layering and from seed, whereas *Picea engelmannii* reproduces almost entirely from seed. Because *Picea engelmannii* live longer, they are nearly always the largest trees in the stand. The only exception occurs in stands where *Picea engelmannii* has been severely attacked by the spruce beetle (*Dendroctonus rufipennis* Kirby) (Schmid and Hinds 1974).

In most stands, *Pinus contorta* and/or *Populus tremuloides* are present as seral species. After disturbance, *Populus tremuloides* may establish initially to be succeeded by *Pinus contorta* which, in turn, is replaced by *Abies lasiocarpa* and *Picea engelmannii. Abies lasiocarpa* and *Picea engelmannii* can reestablish immediately with or without *Pinus contorta* and/or *Populus tremuloides*, depending on the topographic situation, the type of disturbance, and the availability of coniferous tree seed or the sprouting capacity of *Populus*.

This series is represented by 17 stands and 4 habitat types. Basal areas ranged from 188 to 345 square feet per acre (43 to 79 $m^2$/ha). Tree sizes ranged from seedlings to the 28- to 32-inch (7- to 8-dm) d.b.h. class. Tree population and undergrowth data for *Abies lasiocarpa* stands are shown in tables A–1 and A–9.

**Figure 25.—*Abies lasiocarpa/Carex geyeri* habitat type. Seral *Pinus contorta* and *Populus tremuloides* are common components of this habitat type.**

### *Abies lasiocarpa/Carex geyeri*

#### Description

This habitat type is found only west of the Continental Divide, reaching its maximum distribution in the western part of the Arapaho National Forest, including the Dillon District. It occurs on gentle (10–15%) west-facing slopes at lower elevations and on gentle to moderate (10–30%) south-facing slopes at higher elevations. The *A. lasiocarpa/C. geyeri* habitat type is usually drier than the *Abies lasiocarpa/Vaccinium scoparium* habitat type. Soils are Alfisols (Mollic Cryoboralfs and Typic Cryoboralfs). They are shallow to medium depth, coarse-textured, and well-drained, developed in place from sedimentary parent material (table 1).

This habitat type, represented by four stands, is distinguished by the dominance of *Carex geyeri* in the undergrowth, and the scarcity of *Vaccinium scoparium*, and the near absence of *Vaccinium myrtillus* (fig. 25). The overstory dominants are *Abies lasiocarpa* and *Picea engelmannii. Pinus contorta* and *Populus tremuloides* are seral species; but neither seral species shows any significant evidence of long-term self-perpetuation. Important undergrowth species in addition to *Carex geyeri* (17–27% coverage) are *Pachistima myrsinites, Rosa woodsii, Arnica cordifolia, Haplopappus parryi*, and *Lathyrus leucanthus*.

This habitat type was described in the Routt National Forest by Hoffman and Alexander (1980), in the White River National Forest by Hoffman and Alexander (1983) and Hess and Wasser,[5] in the Gunnison National Forest by Komarkova,[8] and in the Medicine Bow National Forest by Alexander et al.[4] This habitat type also has been reported in western Wyoming in Yellowstone National Park and the Teton National Forest (Steele et al. 1983), and in the mountains of central and southern Utah (Youngblood and Mauk 1985). In Montana, an *Abies lasiocarpa/Carex geyeri* habitat type is a minor habitat type, occurring on cold, dry sites (Pfister et al. 1977) but is common in central Idaho on granitic soils (Steele et al. 1981). This habitat type does not occur in the Bighorn

Mountains of Wyoming (Hoffman and Alexander 1976) or in eastern Washington or northern Idaho (Daubenmire and Daubenmire 1968, Cooper et al.[9]).

### Management Implications

Understory vegetation in this habitat type recovers slowly from major disturbance. Tree reproduction in this dry, cold habitat type is more difficult to obtain, and competition between tree seedlings and understory vegetation is more severe than in the *Abies lasiocarpa/Vaccinium scoparium* habitat type. In fact, if tree seedlings are slow to establish after clearcutting, the site may become fully occupied by *Carex geyeri*. *Pinus contorta* is the tree species most likely to compete successfully with *Carex geyeri* following major disturbance. However, *Populus tremuloides* has a high potential to occupy the site following fire.

Timber productivity is average to below average. Cutting methods applicable are similar to those suggested for the *Abies lasiocarpa/Vaccinium scoparium* habitat type; however, seral stands of *Pinus contorta* are more likely to be susceptible to mountain pine beetle in the *Abies lasiocarpa/Carex geyeri* habitat type (Alexander 1986a). Where there is an appreciable amount of either *Pinus contorta* or *Populus tremuloides* in the stands, clearcutting or simulated shelterwood is likely to increase their representation in the new stand. Growing stock levels of 120 to 140 are most appropriate for stands managed for timber (Alexander and Edminster 1980).

This habitat type provides summer forage for livestock and big game. Heavy grazing may reduce the *Carex geyeri* cover and expose soils difficult to revegetate. Natural runoff [12 to 15 inches (30 to 38 cm)] is usually less than in the *Abies lasiocarpa/Vaccinium scoparium* habitat type, but can be increased significantly using the same cutting methods suggested for *A. lasiocarpa/V. scoparium* habitat type.

## *Abies lasiocarpa/Vaccinium scoparium*

### Description

The *Abies lasiocarpa/Vaccinium scoparium* is a major habitat type throughout the Arapaho and Roosevelt National Forests, including the Dillon District. It occurs on nearly level ground to very steep slopes (0–70%) and on all aspects. In general, this habitat type occurs on all subalpine forest sites, which are well-drained, from timberline to the more xeric *Pinus contorta*-dominated habitat types at lower elevations. Soils are Alfisols (Typic Cryoboralfs) and Entisols (Typic Cryoboralfs). They are shallow to medium depth, coarse-textured colluvium, and glacial till that developed in place from a wide variety of parent materials (table 1).

The *A. lasiocarpa/V. scoparium* habitat type is represented by five stands that were climax or near climax. The habitat type is recognized by the almost constant presence and reproductive success of *Abies lasiocarpa* and by the abundance and understory dominance of *Vaccinium scoparium*, sometimes also in association with *Vaccinium myrtillus*. *Picea engelmannii* is present as a self-reproducing co-climax species (fig. 26).

**Figure 26.—*Abies lasiocarpa/Vaccinium scoparium* habitat type. *Picea engelmannii* is a conspicuous codominant in this habitat type.**

The overstory of most of the stands is dominated by *Picea engelmannii*, with *Abies lasiocarpa* as a codominant. *Pinus contorta* is an important seral species and still dominates some of the stands in late stages of succession. However, the self-reproducing species in these stands are *Abies lasiocarpa* and *Picea engelmannii*. *Populus tremuloides* is only an occasional minor seral species. Ground cover varies from sparse to luxuriant. In general, undergrowth species richness declines from seral to climax successional stages and from young to old stands. In addition to *Vaccinium scoparium* and *Vaccinium myrtillus*, which constitute more than 50% of the coverage, other important undergrowth species are *Arnica cordifolia*, *Epilobium angustifolium*, and *Polemonium delicatum*.

The *Abies lasiocarpa/Vaccinium scoparium* habitat type, or others very similar to it, occur throughout the Rocky Mountains (Hoffman and Alexander 1976, 1980, 1983; Mauk and Henderson 1984; Moir and Ludwig 1979; Pfister et al. 1977; Steele et al. 1981, 1983; Alexander et al.[4]). However, there is considerable variability in the coverage of *Vaccinium scoparium* within this habitat type. Additionally, more broad-leaved herbaceous dicots occur in this habitat type on the western slope of the Rockies than on the eastern slope.

### Management Implications

Timber productivity varies considerably (Alexander 1967). Understory vegetation changes slowly after major disturbance, and competition is not severe between tree seedlings and understory vegetation, except where coverage of herbaceous dicots is high. Reproduction may be difficult to obtain on south slopes and other dry situations. There may be a manageable stand of advanced reproduction in much of this habitat type.

While most silvicultural systems can be used (Alexander 1986a), complete removal of the mature overstory by clearcutting in mixed stands, where *Pinus contorta* makes up part of the overstory, may result in an even-aged replacement stand of seral *Pinus contorta*. This also can happen with the final harvest cut under shelterwood methods, unless extreme care is taken in logging to protect advanced regeneration of *Abies lasiocarpa* and *Picea engelmannii*. In these mixed stands, using a standard or modified shelterwood system, the proportion of *Pinus contorta* retained in the first cut can be used to manipulate the amount of *Abies lasiocarpa* and *Picea engelmannii* in the stand. Clearcutting, even in small 3- to 5-acre (1- to 2-ha) or 400-foot wide (122-m) openings, is likely to eliminate the chance for regeneration of *P. engelmannii* on southerly exposures for extremely long periods of time.

Where protection from direct solar radiation and excessive soil moisture losses is necessary for survival of *P. engelmannii* seedlings, standard or modified shelterwood are appropriate even-aged cutting methods. *Pinus contorta* may have to be planted on south aspects to maintain forest cover if clearings occur or are desired.

Uneven-aged management with group selection and/or individual-tree selection cutting can be used in irregular-structured stands, or where the combination of openings and high forest is required to enhance recreational opportunities and amenity values. Group selection is likely to perpetuate the existing species mix but may increase the proportion of *Pinus contorta*.

Individual-tree selection will favor *Abies lasiocarpa* over *Picea engelmannii*, and in mixed stands, the proportion of both *A. lasiocarpa* and *P. engelmannii* will be increased, especially if the initial cutting removes a large proportion of *Pinus contorta*. Growing stock levels of 120 to 160 are appropriate for stands managed for timber (Alexander and Edminster 1980).

The *Abies lasiocarpa/Vaccinium scoparium* habitat type is not heavily used by livestock, but is big game summer range. This habitat type also provides habitat for many birds and mammals. It occupies areas with the greatest potential for water yield [up to 15 inches (38 cm) of natural runoff annually] on the Arapaho and Roosevelt National Forests. Small patch [3- to 5-acre (1.2- to 2.0-ha)] or strip [400-foot (122-m)] clearcuts result in greater forage production for big game and larger increases in water available for streamflow than either shelterwood, group selection, or individual-tree selection cutting (Alexander 1977, Alexander and Edminster 1980, Leaf 1975, Leaf and Alexander 1975, Regelin and Wallmo 1978, Wallmo et al. 1972). If larger openings are cut, slash should be left in place to create surface roughness needed to retain snowpack.

Streamflow can be increased with partial cutting on north slopes; but the increase will be greater with clearcutting (Troendle and Meiman 1984). Because of the increase in tree reproduction, forage production begins to decline in about 15 to 20 years, and water production in 20 to 30 years. Therefore, new openings must be cut periodically to maintain increases in forage and water.

## *Abies lasiocarpa/Senecio triangularis*

### Description

The *Abies lasiocarpa/Senecio triangularis* is a minor habitat type throughout the Arapaho and Roosevelt National Forests. It occurs on moderate to steep (10–55%) slopes with variable aspects. This habitat type is restricted to concave land surfaces that are inundated by snowmelt runoff. The *A. lasiocarpa/S. triangularis* habitat type occurs in a wetter environment than *Abies lasiocarpa/Vaccinium scoparium* habitat type. Soils are primarily Alfisols and Inceptisols (Typic Cryoboralfs, and Entic and Aquic Cryumbrepts). They are moderately deep colluvium and alluvium developed from granitic and other igneous rock (table 1). Soils are generally well-drained at the beginning of the growing season but remain at or near field capacity during the growing season.

This habitat type, represented by four stands, is recognized by the overstory dominance and reproductive success of *Abies lasiocarpa* and *Picea engelmannii* and the dominance of the undergrowth by *Senecio triangularis* (17–35% coverage) (fig. 27). The only shrubs present are *Vaccinium myrtillus* and *V. scoparium*. Herbaceous species include *S. triangularis, Arnica cordifolia, Caltha leptosepala, Mertensia ciliata, Mitella pentandra, Trollius laxus*, and *Veronica wormskjoldii*.

Komarkova[8] reported this habitat type on the Gunnison National Forest in western Colorado; but it has not been observed elsewhere. Mauk and Henderson (1984) and Steele et al. (1983) reported a *Picea engelmannii/Caltha leptosepala* habitat type in northern Utah, and northwestern Wyoming and southeastern Idaho that has many of the associated undergrowth species found in the *A. lasiocarpa/S. triangularis* habitat type. Cooper et al.[9] and Steele et al. (1981, 1983) also reported an *Abies lasiocarpa/Streptopus amplexifolius* habitat type in northwestern Utah and southern Idaho that closely approximates the *A. lasiocarpa/S. triangularis* habitat type described here.

### Management Implications

Timber productivity in this habitat type is average to above average; but the high water table associated with the habitat type severely hampers any timber management activity, including road construction and maintenance. Road and trail costs are expected to be maximum in this habitat type. Moreover, the small area occupied by the habitat type limits its importance as a timber resource. Clearcutting will cause the water table to rise to the ground surface and preclude establishment of tree species. Partial cutting increases the risk of blowdown. Forage production for livestock is moderately high; but the potential for trampling damage and soil compaction is also high. The potential for increasing streamflow may be high; but management for water production is not a viable alternative because of the effect timber harvesting has on the water table and soil compaction. The principal value of the *A. lasiocarpa/S.*

*triangularis* habitat type is for watershed and streamside protection, big game summer range, and habitat for birds and small mammals.

### *Abies lasiocarpa/Calamagrostis canadensis*

#### Description

This minor habitat type is conspicuous and widely distributed throughout the Arapaho and Roosevelt National Forests. The *Abies lasiocarpa/Calamagrostis canadensis* habitat type has the coldest and wettest environment in the *Abies lasiocarpa* series because of high ground water levels and cold air drainage from surrounding uplands. It occurs in bottomlands on benches adjacent to streams on level to gentle (0–10%) topography. Soils are primarily Mollisols (Typic Cryaquolls). Despite the cold, wet environment, soils are primarily mineral, with a high organic content. They are derived from alluvium and colluvium parent materials of mixed minerology (table 1), and are poorly-drained.

This habitat type, represented by four stands, is distinguished by an open-canopy dominated by *Abies lasiocarpa* and *Picea engelmannii*. *Populus tremuloides* is a seral species in some stands. The undergrowth is dominated by *Calamagrostis canadensis* (25–45% coverage) (fig. 28). Shrub associates include *Lonicera involucrata*, *Ribes lacustre*, *Vaccinium myrtillus*, and *V. scoparium*. Important graminoids are *C. canadensis*, *Carex aquatilis*, *Carex disperma*, *Carex festivella*, *Carex media*, *Luzula parviflora*, and *Poa reflexa*. Major forbs include *Arnica cordifolia*, *Equisetum arvense*, *Mertensia ciliata*, *Mitella pentandra*, *Osmorhiza depauperata*, *Pyrola chlorantha*, *Saxifraga arguta*, *Senecio triangularis*, and *Smilacina stellata*.

An *Abies lasiocarpa/Calamagrostis canadensis* habitat type has been reported on the Gunnison National Forest by Komarkova.[8] Further north, an *A. lasiocarpa/C. canadensis* habitat type with similar ecologic, if not floristic similarity, has been reported in northern Idaho by Cooper et al.,[9] in central Idaho by Steele et al. (1981),

**Figure 27.—*Abies lasiocarpa/Senecio triangularis* habitat type. This stand occurs as a narrow forested strip along a seasonally wet area caused by snowmelt runoff.**

**Figure 28.—*Abies lasiocarpa/Calamagrostis canadensis* habitat type. Soils in this habitat type remain wet to moist for most of the growing season, resulting in a dense *C. canadensis* undergrowth.**

in Montana by Pfister et al. (1977), in southeastern Idaho and northwestern Wyoming by Steele et al. (1983), and in northern Utah by Mauk and Henderson (1984).

#### Management Implications

The management implications for this habitat type are similar to the *Abies lasiocarpa/Senecio triangularis* habitat type. This habitat type is more difficult to regenerate, however, especially if it is clearcut, because of intense competition from undergrowth species, saturated soils, and cold sites. Because of the high water table, partial cutting is likely to result in heavy windthrow. As noted previously, clearcutting causes the water table to rise to the ground surface. Therefore, this habitat type should be avoided for road, trial, or recreational development because of saturated soils and the potential for soil compaction and mass movement. The *A. lasiocarpa/C. canadensis* habitat type may have moderately high potential for livestock forage production; but grazing should be avoided when soils are saturated because of potential for trampling damage. The value of this habitat type is for watershed protection and wildlife habitat; however, trampling damage by big game animals can cause soil compaction and subsequent erosion.

## *PINUS ARISTATA* SERIES

*Pinus aristata* is not a major forest tree species on the Arapaho and Roosevelt National Forests. It occurs just below timberline at elevations ranging from 11,240 to 11,645 feet (3,425 to 3,550 m) (table 1). This series is represented by four stands, all in the southern Arapaho National Forest. Only one habitat type has been recognized in this series. Basal areas on the study plots ranged from 205 to 278 square feet per acre (47 to 64 $m^2$/ha). Tree sizes ranged from seedlings to the $\geq$32-inch ($\geq$8-dm) d.b.h. class. Tree populations and undergrowth data for the *Pinus aristata* stands are shown in tables A–1 and A–10.

### *Pinus aristata/Trifolium dasyphyllum*

#### Description

This habitat type is a restricted but conspicuous landscape unit on the Arapaho National Forest. It occurs on moderate to steep (25–50%) slopes, with variable aspects on high mountain slopes that interface between subalpine forests and alpine tundra. The environment is harsh and xeric with desiccating winds and broadly fluctuating temperatures. Soils are minimally developed Entisols (Typic Cryorthents). They are shallow, coarse-textured, derived in place from primarily granitic parent materials (table 1).

The *Pinus aristata/Trifolium dasyphyllum* habitat type is recognized by a moderately closed tree canopy dominated by *Pinus aristata* and an undergrowth dominated by *Trifolium dasyphyllum* (10–12% coverage) (fig. 29). *Picea engelmannii* is a minor associate. Shrubs are absent or inconspicuous in the undergrowth. Important graminoids are *Calamagrostis purpurascens, Carex foenea, Festuca brachyphylla, Poa* spp., and *Trisetum spicatum*. In addition to *T. dasyphyllum*, major forbs include *Achillea lanulosa, Allium geyeri, Arenaria fendleri, Penstemon whippleanus, Polemonium delicatum, Sedum stenopetalum*, and *Solidago decumbens*. The *P. aristata/T. dasyphyllum* habitat type has not been reported elsewhere.

#### Management Implications

The potential of this habitat type for timber and forage production is very low. There is no potential for increasing natural runoff. Cutting timber, grazing, road construction, and other disturbances in this habitat type are likely to be devastating to existing vegetation. Recovery is extremely slow—it may take hundreds of years. The principal value of this habitat type is watershed protection and the usually pleasing appearance of the old and gnarled *Pinus aristata*.

**Figure 29.—*Pinus aristata/Trifolium dasyphyllum* habitat type. Except for difference in dominant overstory canopy and geographical distribution, this habitat type is similar to the *Pinus flexilis/T. dasyphyllum* habitat type.**

## RIPARIAN HABITAT TYPES

Riparian vegetation where tree species are important occurs on benches and floodplains along the east slope of the Front Range, in the Roosevelt National Forest. These areas are dominated by *Populus angustifolia* at lower elevations and *Picea pungens* at higher elevations.

### *PICEA PUNGENS* SERIES

*Picea pungens* is not a major tree species along the Front Range of Colorado. It occurs in riparian areas at elevations of 7,465 to 8,860 feet (2,275 to 2,700 m) (table 1). This series is represented by four plots, all on the Roosevelt National Forest. Only one habitat type has been recognized in this series. Basal areas on the study plots range from 169 to 360 square feet per acre (49 to 83 $m^2/ha$). Tree sizes range from seedling to an occasional individual in the $\geq$32-inch ($\geq$8-dm) d.b.h. class. Tree populations and undergrowth data for the *Picea pungens* stands are shown in tables A–1 and A–11.

### *Picea pungens/Arnica cordifolia*

#### Description

The *Picea pungens/Arnica cordifolia* is a minor but highly conspicuous habitat type. It occurs on level to nearly level (0–10%) benches, adjacent to streams, which occupy well-drained, narrow bottomlands flanked by gentle to steep slopes and canyon sides. Cold-air drainage combined with situations where this habitat type occurs creates a very mesic environment, more characteristic of higher elevations. Soils are mostly Mollisols (Argic Pachic and Pachic Cryoborolls). They are well-developed, deep, sandy loams derived from fluvium and alluvium deposits (table 1).

The *P. pungens/A. cordifolia* habitat type is recognized by the dominance and reproductive success of *P. pungens* in the overstory and *A. cordifolia* (15–31% coverage) in the undergrowth (fig. 30). *Abies lasiocarpa, Pinus contorta, Populus tremuloides*, and *Pseudotsuga menziesii* are common overstory associates. *Juniperus communis* and *Rosa woodsii* represent the depauperate shrub layer. Major graminoids are *Agropyron trachycaulum, Bromus anomalus, Carex disperma*, and *Oryzopsis asperifolia*. Important forbs include *A. cordifolia, Achillea lanulosa, Equisetum arvense, Fragaria ovalis, Galium boreale, Osmorhiza depauperata*, and *Smilacina stellata*.

The *P. pungens/A. cordifolia* habitat type has not been reported elsewhere; but Moir and Ludwig (1979) and Fitzhugh et al.[7] identified a *P. pungens/Poa pratensis* habitat type in northern New Mexico, which is similar to the *P. pungens/A. cordifolia* habitat type. Hoffman and Alexander (1983) identified a *P. pungens/Poa* spp. habitat type on the White River National Forest in Colorado; however, it is an upland habitat type that bears little resemblance to the *P. pungens/A. cordifolia* habitat type previously described.

### Management Implications

The primary value of this riparian, bottomland habitat type is for recreational use and to provide food and cover for wildlife. Timber production potential is relatively high; but the value for timber is low. Any timber harvesting should be light, either with a shelterwood or selection cutting to reduce the likelihood of associated species replacing *P. pungens*. The initial entry should remove the smaller trees, because cutting the large trees is likely to result in top breakage to the smaller trees. The potential for increasing forage production is high, especially where past use has decreased the amount of *Carex* spp. and increased *Poa* spp. However, any timber harvesting or livestock use must be rigidly controlled, because of the sensitivity of soils and landforms to disturbance. Because this is a favorite habitat for elk, with good cover and long-term palatability of forage, any cutting that increases forage production improves elk habitat, as long as adequate hiding cover is retained. The potential for increasing water yield is high, but management directed toward this objective is likely to raise the water table with the subsequent loss of tree species.

## *POPULUS ANGUSTIFOLIA* SERIES

*Populus angustifolia* is a deciduous forest tree species of the upper foothills and lower montane zones along the Front Range. It occurs in riparian areas such as narrow benches of small streams and in the floodplains of larger streams, at elevations of 6,560 to 7,790 feet (2,000 to 2,375 m) (table 1). This series is represented by four plots and one habitat type, all on the Roosevelt National Forest. Basal areas range from 126 to 249 square feet per acre (29 to 57 $m^2$/ha). Tree sizes range from seedlings to the 16- to 20-inch (4- to 5-dm) d.b.h. class. Tree population and undergrowth data for the *Populus angustifolia* stands are shown in tables A–1 and A–12.

### *Populus angustifolia/Salix exigua*

### Description

This habitat type, confined to the east slopes of the Front Range, occurs generally on level to near level terrain that is subject to spring flooding. Soils are Entisols (Mollic and Aquic Ustifluvents, and Mollic Fluvaquents). They are alluvium and colluvium derived from parent materials of mixed geologic origins (table 1).

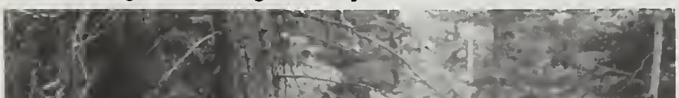

**Figure 30.—*Picea pungens/Arnica cordifolia* habitat type. Scattered individuals of *Pseudotsuga menziesii* and *Populus tremuloides* are present in this stand.**

**Figure 31.—*Populus angustifolia/Salix exigua*. The climax overstory of *P. angustifolia* has an understory of seral species, such as *Poa pratensis* and *Bromus inermus*. *S. exigua* is poorly represented.**

The *Populus angustifolia/Salix exigua* habitat type is characterized by a climax forest vegetation dominated by *P. angustifolia* in the overstory and *S. exigua* (8–19% coverage) in the understory (fig. 31). Minor tree components include *Juniperus scopulorum*, *Picea pungens*, *Pinus ponderosa*, and *Populus tremuloides*. The tall shrub stratum is densely populated with such species as *S. exigua*, *Salix* spp., *Alnus tenuifolia*, *Betula occidentalis*, and *Cornus stolonifera*. Low shrubs are *Rosa woodsii* and *Symphoricarpos occidentalis*. Major herbaceous species include *Agropyron trachycaulum*, *Bromus anomalus*, *Calamagrostis canadensis*, *Carex* spp., *Galium boreale*, *Heracleum lanatum*, *Smilacina stellata*, and *Vicia americana*.

Heavy utilization of *P. angustifolia/S. exigua* for grazing and recreation has resulted in significant vegetational changes on many sites representing this habitat type. Consequently, many sites now support introduced species, such as *Poa pratensis*, *Bromus inermis*, *Taraxacum officinale*, and *Trifolium repens*. In these circumstances, the existing vegetation may be termed a zootic climax. Komarkova[8] reported a similar *P. angustifolia/S. exigua* habitat type on the Gunnison National Forest.

### Management Implications

Timber production is moderate; but *P. angustifolia*, which makes up most of the volume in this habitat type, is not a commercial forest tree species. Forage production potential for livestock and big game may be high; but heavy grazing pressure in the past has caused production to be low. Grazing pressure has reduced shrubs and increased the proportion of less palatable graminoids. Diversified recreation use and roadbuilding is heavy because of close proximity to water. This habitat type provides food and cover for a wide variety of nongame wildlife.

## KEY TO THE FOREST HABITAT TYPES OF THE ARAPAHO/ROOSEVELT NATIONAL FORESTS

1. Coniferous trees dominant and reproducing; deciduous trees may be present, but are rare and are not reproducing sufficiently to become dominant.
  2. Overstory canopy very open and dominated by *Juniperus scopulorum* stands at lower elevations, usually below the *Pinus ponderosa* zone; *J. scopulorum* the self-reproducing species. Other conifers absent or rare.
    3. *Cercocarpus montanus* clearly dominates the undergrowth; other shrubs present but not dominant. ---------------------------------------- *JUNIPERUS SCOPULORUM/CERCOCARPUS MONTANUS*
    3. *Cercocarpus montanus* absent; undergrowth dominated by *Artemisia tridentata* or *Purshia tridentata.* — 4
      4. Undergrowth dominated by *Artemisia tridentata; Purshia tridentata, Agropyron griffithsii,* and *Muhlenbergia montana* absent or poorly represented. ------- *JUNIPERUS SCOPULORUM/ARTEMISIA TRIDENTATA*
      4. Undergrowth dominated by *Purshia tridentata; Artemisia tridentata, Elymus glaucus,* and *Ribes cereum* absent or scattered. --------------------------- *JUNIPERUS SCOPULORUM/PURSHIA TRIDENTATA*
  2. Overstory not dominated by *Juniperus scopulorum* which may be present as a seral species. Other conifer(s) dominant and reproducing.
    5. *Pinus ponderosa* dominant and self-reproducing; other conifers absent or, if present, not reproducing.
      6. Undergrowth dominated by shrubs; graminoids present but not dominant.
        7. *Cercocarpus montanus* dominates the undergrowth; *Purshia tridentata* absent or sparse. ---------------------------------------------- *PINUS PONDEROSA/CERCOCARPUS MONTANUS*
        7. *Purshia tridentata* dominates the undergrowth; *Cercocarpus montanus* absent or sparse. ---------------------------------------------- *PINUS PONDEROSA/PURSHIA TRIDENTATA*
      6. Undergrowth dominated by graminoids; shrubs not common.
        8. *Hesperochloa kingii* clearly dominates a rather sparse undergrowth; *Muhlenbergia montana* and *Carex rossii* absent or uncommon. ---------------------------- *PINUS PONDEROSA/HESPEROCHLOA KINGII*
        8. *Hesperochloa kingii* may be present, but not dominant.
          9. *Carex rossii* dominates the undergrowth; *Muhlenbergia montana* also may be important; *Agropyron griffithsii* may be present, but not dominant. ------------------- *PINUS PONDEROSA/CAREX ROSSII*
          9. *Carex rossii* may be present, but not dominant; *Muhlenbergia montana* usually dominant; *Agropyron griffithsii* may be codominant. ------------------- *PINUS PONDEROSA/MUHLENBERGIA MONTANA*
    5. Pinus ponderosa absent, rare, or clearly seral. Other conifers present and reproducing successfully.
      10. *Pseudotsuga menziesii* climax and reproducing successfully, especially on steep, northerly slopes. Other conifers may be present, but not reproducing vigorously and not climax.
        11. Undergrowth dominated by graminoids; shrubs absent or sparse.
          12. *Carex rossii* dominates the undergrowth; *Carex geyeri, Pachistima myrsinites,* and *Symphoricarpos oreophilus* absent or sparse. ---------------------------- *PSEUDOTSUGA MENZIESII/CAREX ROSSII*
          12. *Carex geyeri* abundant and dominates the undergrowth; *Carex rossii, Pachistima myrsinites,* and *Symphoricarpos oreophilus* may be present but not dominant. *PSEUDOTSUGA MENZIESII/CAREX GEYERI*
        11. Undergrowth dominated by shrubs; graminoids present but not dominant.
          13. *Physocarpus monogynus* dominant in the undergrowth; *Jamesia americana, Symphoricarpos oreophilus,* and *Hesperochloa kingii* also important but not dominant. ---------------------------------------- *PSEUDOTSUGA MENZIESII/PHYSOCARPUS MONOGYNUS*
          13. *Jamesia americana* dominates the undergrowth; *Physocarpus monogynus* present but not dominant; *Symphoricarpos oreophilus* and *Hesperochloa kingii* absent or rare. ---------------------------------------- *PSEUDOTSUGA MENZIESII/JAMESIA AMERICANA*
      10. *Pseudotsuga menziesii* may be present, but not reproducing vigorously, not climax. Other conifers present and self-reproducing.
        14. *Picea pungens* climax and reproducing successfully; *Salix* spp. absent to sparse. Other conifers may be present but not climax. ------------------------------ *PICEA PUNGENS/ARNICA CORDIFOLIA*
        14. *Picea pungens* absent; other conifers present and reproducing vigorously.
          15. *Pinus flexilis* present, dominant, and reproducing. Other conifers may be present but not reproducing vigorously.
            16. *Juniperus communis* dominates the undergrowth; herbaceous species poorly represented, but *Hesperochloa kingii* may be present; *Calamagrostis purpurascens* and *Trifolium dasyphyllum* absent or rare. ---------------------------------------------- *PINUS FLEXILIS/JUNIPERUS COMMUNIS*
            16. Herbaceous vegetation dominates the undergrowth; shrubs poorly represented.
              17. *Trifolium dasyphyllum* dominates the undergrowth; *Calamagrostis purpurascens, Penstemon whippleanus, Mertensia viridis,* and *Oreoxis alpina* are characteristic. ---------------------------------------------- *PINUS FLEXILIS/TRIFOLIUM DASYPHYLLUM*
              17. *Trifolium dasyphyllum* rare or absent; *Calamagrostis purpurascens* dominates the undergrowth. ---------------------------------------- *PINUS FLEXILIS/CALAMAGROSTIS PURPURASCENS*
          15. *Pinus flexilis* absent or sparse. Other conifers reproducing vigorously.

18. *Pinus contorta* dominant and climax. Other conifers may be present but not reproducing vigorously.
19. Shrubs dominate the undergrowth; *Carex geyeri* not common.
20. Sparse undergrowth dominated by *Juniperus communis*; *Arctostaphylos uva-ursi* may also be important. ———————————————— *PINUS CONTORTA/JUNIPERUS COMMUNIS*
20. Undergrowth not dominated by *Juniperus communis*, although it may be locally abundant.
21. Undergrowth dominated by *Shepherdia canadensis*; *Vaccinium scoparium* also present as a lower layer. ———————————— *PINUS CONTORTA/SHEPHERDIA CANADENSIS*
21. Undergrowth dominated by *Vaccinium scoparium*; *Shepherdia canadensis* may also be present but not dominant. ———————————— *PINUS CONTORTA/VACCINIUM SCOPARIUM*
19. Shrubs poorly represented in the undergrowth; *Carex geyeri* present and dominates undergrowth. ———————————————— *PINUS CONTORTA/CAREX GEYERI*
18. *Pinus contorta* absent, or not reproducing vigorously and not climax. Other conifers self-reproducing.
22. *Picea engelmannii* present, reproducing successfully, and climax. Other conifers may be present but not reproducing vigorously and not climax; forests may be partially of Krummholz form. ———————————— *PICEA ENGELMANNII/TRIFOLIUM DASYPHYLLUM*
22. *Picea engelmannii* may be abundant and reproducing, but is not the sole climax dominant.
23. *Abies lasiocarpa* present and reproducing most successfully; *Picea engelmannii* may dominate overstory and reproduce successfully, but there is no evidence of replacement of *Abies lasiocarpa*; *Populus tremuloides* and *Pinus contorta* may be present but not reproducing successfully, and not climax.
24. *Vaccinium scoparium* dominates the undergrowth; *Vaccinium myrtillus*, *Carex geyeri*, and *Arnica cordifolia* present but not dominant. ———— *ABIES LASIOCARPA/VACCINIUM SCOPARIUM*
24. *Vaccinium* spp. and other shrubs may be present, but undergrowth is dominated by herbaceous species.
25. *Senecio triangularis* dominates the undergrowth. ———————————— *ABIES LASIOCARPA/SENECIO TRIANGULARIS*
25. Graminoids well represented and dominate the undergrowth; *Senecio triangularis* not dominant.
26. *Carex geyeri* abundant; dominates the undergrowth; shrubs sparse. ———————————— *ABIES LASIOCARPA/CAREX GEYERI*
26. *Calamagrostis canadensis* dominates the undergrowth; *Carex* spp., *Senecio triangularis*, and various shrubs well represented, but none are dominant. ———————————— *ABIES LASIOCARPA/CALAMAGROSTIS CANADENSIS*
23. *Pinus aristata* dominant and climax; *Picea engelmannii* may be present. Other conifers absent. ———————————— *PINUS ARISTATA/TRIFOLIUM DASYPHYLLUM*
1. Coniferous trees absent or minor; deciduous trees present and reproducing successfully.
27. *Populus angustifolia* present and reproducing successfully; conifers and *Populus tremuloides* may be present but not dominant; *Salix* spp. well represented. ———— *POPULUS ANGUSTIFOLIA/SALIX EXIGUA*
27. *Populus angustifolia* and *Salix* spp. absent or poorly represented; *Populus tremuloides* present and reproducing successfully; conifers and other deciduous species may be present but not dominant.
28. *Festuca thurberi* abundant and dominates the undergrowth; *Agropyron trachycaulum*, *Elymus glaucus*, and *Symphoricarpos oreophilus* may be present; forbs not important in the undergrowth. ———————————— *POPULUS TREMULOIDES/FESTUCA THURBERI*
28. *Festuca thurberi*, *Agropyron trachycaulum*, *Elymus glaucus*, and *Symphoricarpos oreophilus* absent; undergrowth dominated by other graminoids or forbs.
29. *Carex geyeri* conspicuously abundant and dominates the undergrowth; *Thalictrum fendleri* and *Ligusticum porteri* absent or not abundant. ———————— *POPULUS TREMULOIDES/CAREX GEYERI*
29. *Carex geyeri* not dominant; either/or both *Thalictrum fendleri* and *Ligusticum porteri* dominate the undergrowth. ———————————— *POPULUS TREMULOIDES/THALICTRUM FENDLERI*

The distribution and successional status of tree species in relation to habitat type are shown in table 2.

## DISCUSSION

### VALIDITY OF HABITAT TYPE CLASSIFICATION

The practical value of the habitat type classifications has only begun to be realized as it relates to vegetation mapping, tree growth, tree susceptibility to diseases, production of browse species for game animals, and in providing a framework within which to relate additional basic or applied biological studies (Daubenmire 1961, 1973, 1976).

The classification system, while using vegetation as the indicator of site potentials, combines available related information on soil and climate. While initially using vegetation as the criterion of delimiting habitat types, this approach also takes a holistic view of units of land area. The older the stands observed, the more closely they approximate the potential (climax or near climax) of the landscape units studied (Daubenmire 1976).

This classification system utilizes both overstory and undergrowth vegetation in recognizing habitat types. In this study, the major vegetation zones are dominated by *Pinus ponderosa*, *Pseudotsuga menziesii*, *Pinus contorta*, *Abies lasiocarpa*, and *Picea engelmannii*. It is apparent that the *Pinus contorta* zone on the Arapaho and Roosevelt National Forests and elsewhere in Colorado is

Table 2.—The ecologic roles of tree species in habitat types on the Arapaho and Roosevelt National Forests.

| Habitat type \ Species | *Juniperus scopulorum* | *Populus angustifolia* | *Pinus ponderosa* | *Pinus flexilis* | *Picea pungens* | *Pseudotsuga menziesii* | *Populus tremuloides* | *Pinus concorta* | *Pinus aristata* | *Picea engelmannii* | *Abies lasiocarpa* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Juniperus scopulorum/Cercocarpus montanus* | C | | o | | | o | | | | | |
| *Juniperus scopulorum/Purshia tridentata* | C | | o | | | o | | | | | |
| *Juniperus scopulorum/Artemisia tridentata* | C | | o | | | o | | | | | |
| *Populus angustifolia/Salix exigua* | o | C | o | | o | | o | | | | |
| *Pinus ponderosa/Cercocarpus montanus* | | | C | | | o | | | | | |
| *Pinus ponderosa/Purshia tridentata* | s | | C | | | s | | | | | |
| *Pinus ponderosa/Muhlenbergia montana* | s | | C | o | | s | | | | | |
| *Pinus ponderosa/Carex rossii* | o | | C | | | o | | | | | |
| *Pinus ponderosa/Hesperochloa kingii* | | | C | s | | s | | | | | |
| *Pseudotsuga menziesii/Carex rossii* | s | | S | | | C | | | | | |
| *Pseudotsuga menziesii/Carex geyeri* | s | | | | | C | | | | | |
| *Pseudotsuga menziesii/Physocarpus monogynus* | S | | S | | | C | | o | | | |
| *Pseudotsuga menziesii/Jamesia americana* | S | | S | | | C | | | | | |
| *Picea pungens/Arnica cordifolia* | | | o | | C | o | S | o | | | o |
| *Populus tremuloides/Festuca thurberi* | | | | o | | | C | | | o | o |
| *Populus tremuloides/Carex geyeri* | | | | o | | | C | o | | o | o |
| *Populus tremuloides/Thalictrum fendleri* | | | | o | | | C | o | | | o |
| *Pinus flexilis/Juniperus communis* | o | | c | C | | o | S | c | | | o |
| *Pinus flexilis/Calamagrostis purpurascens* | | | | C | | | | o | | o | |
| *Pinus flexilis/Trifolium dasyphyllum* | | | | C | | | | | | o | o |
| *Pinus contorta/Juniperus communis* | | | o | | | | S | C | | o | |
| *Pinus contorta/Carex geyeri* | | | | | | | S | C | | o | |
| *Pinus contorta/Shepherdia canadensis* | | | | | | o | S | C | | o | o |
| *Pinus contorta/Vaccinium scoparium* | | | | | | | | C | | o | o |
| *Picea engelmannii/Trifolium dasyphyllum* | | | | | | | | | o | C | o |
| *Abies lasiocarpa/Carex geyeri* | | | | | | | S | S | | C | C |
| *Abies lasiocarpa/Vaccinium scoparium* | | | | | | | | S | | C | C |
| *Abies lasiocarpa/Senecio triangularis* | | | | | | | | S | | C | C |
| *Abies lasiocarpa/Calamagrostis canadensis* | | | | | | | S | | | C | C |
| *Pinus aristata/Trifolium dasyphyllum* | | | | | | | | | C | c | |

*C = Major Climax Species; c = minor climax species; S = Major Seral Species; s = minor seral species; o = occasional species.*

warmer and drier than the *Abies* zone. Edaphic factors are also more alike within than between zones.

The classification of habitat types recognizes climax tree species in an area; these are given primary consideration, and important seral species are noted. Undergrowth vegetation is then used to indicate habitat types within the zone where a given tree species is climax.

## DISTRIBUTION PATTERNS OF FOREST TREE SPECIES

The distribution of forest habitat types across the landscape of the Arapaho and Roosevelt National Forests is a function of several environmental factors, all of which are individually identifiable, but none of which is functionally independent. The habitat types described in this study are units that are visually separable on the basis of their biotic expression and analytically distinct on the basis of the environmental parameters that encompass them. This study identified forest habitat types in terms of their vegetational features and physical characteristics. However, one of the practical effects of this approach has been to reveal the relationship between major environmental gradients and the vegetational composition and distributional pattern of forest habitat types.

Three macro-environmental gradients control the broad, transzonal features of vegetation and the general mosaic of habitat type placement on the landscape. Altitude-induced climatic changes are responsible for the discrete vegetation zones characterizing the study area. Major physiognomic transformations occur as the elevational gradient is traversed. The relative distribution of the habitat types by physiognomic category in the Arapaho and Roosevelt National Forests corresponds closely to this gradient. The spatial occurrence of habitat types within series is partially attributable to altitude, in several instances. Within the *Pinus flexilis* series, the three representative habitat types are aligned on an elevational gradient, along which significant vegetational changes occur.

Geologic, edaphic, and climatic variations, resulting from a geographical macro-gradient within the study area, also influences the distributional pattern of habitat types as well as their vegetational composition. The Continental Divide separates the study area in two geographically distinct regions. Geological differences between the two sides of the Continental Divide are conspicuous. Except for sedimentary rock at the base of the foothills, the eastern flank of the Front Range is composed primarily of igneous and metamorphic rocks. West of the Continental Divide, sedimentary rock is more prevalent, particularly in the southern Park Range. Edaphic differences accompany this differential distribution of geological materials. Soils on the eastern slope frequently are derived from more resistant parent materials than soils found further west. Contrasting edaphic features between habitat types of the *Pseudotsuga menziesii* and *Pinus contorta* series on both sides of the Continental Divide illustrate this point.

Climatic changes arising from the precipitation barrier effect of the Continental Divide constitute the most pronounced effect of this geographical macro-gradient. In particular, precipitation levels are significantly greater west of the Divide than on the eastern flank of the northern Front Range. The result of this regional dichotomy is seen clearly in the differential distribution of habitat types of the *Pseudotsuga menziesii* and *Pinus contorta* series between the two climatic regions. The *Pseudotsuga menziesii/Carex geyeri* habitat type and the *Pinus contorta/Carex geyeri* habitat type are specific to lands west of the Continental Divide. The *Pseudotsuga menziesii/Physocarpus monogynus* and *Pinus contorta/Juniperus communis* habitat types are respective eastern slope counterparts occupying similar elevational ranges and topographic positions. The prevalence of *Carex geyeri* among the former habitat types and its conspicuous absence among the latter is attributable primarily to geographically-induced climatic differences between the two areas of habitat type occurrence.

Differences in floristic composition within the Arapaho and Roosevelt National Forests are attributable to latitudinal as well as passive geographical macro-gradients. The existence of two habitat types (*Pinus flexilis/Trifolium dasyphyllum* and *Pinus aristata/T. dasyphyllum*), occupying nearly identical environments, but at different latitudinal locations, is the result of the unique dispersal pattern of *Pinus aristata* and the ecological similarity existing between it and *Pinus flexilis*. Floristic differences accountable to the geographical macro-gradient are also evident. *Pachistima myrsinites*, for instance, is a major component of habitat types of both the *Pseudotsuga menziesii* and *Pinus contorta* series—but only west of the Continental Divide.

These altitudinal, geographical, and latitudinal macro-gradients determine only the general pattern of habitat type placement and vegetational change within the Arapaho and Roosevelt National Forests. Spatial distribution of habitat types at approximately equivalent elevational ranges and of similar geographical locations is controlled by soil moisture micro-gradients associated with local edaphic and topographic conditions. Spatial juxtaposition of habitat types supporting conspicuously different vegetation or principal floristic components is an ecological expression of the pervasive influence of soil moisture regimes on ecosystem structure and function. The determinant of any particular soil moisture regime is a complex function of numerous environmental factors, among which soils, aspect, slope angle and position, and landscape relief are the most important. Changes among factor combinations constituting the soil-moisture regime produce a soil-moisture gradient.

A major toposequence of habitat types is found in the subalpine region of the study area. The *Abies lasiocarpa/Vaccinium scoparium* habitat type occupies mesic, upland positions. Yet, on increasingly lower topographic positions, a wetter habitat type (*Abies lasiocarpa/Calamagrostis canadensis*) is found.

Edaphic sequences also are common among the habitat types of the Arapaho and Roosevelt National Forests. In particular, the spatial juxtaposition of grassland and forestland sites in the montane and subalpine zones of the study area reflect fundamentally different soil moisture regimes arising from dissimilar edaphic environments. In the lower montane zone, for instance, *Pinus ponderosa* is the predominant coniferous species and is considered the climax vegetation type. However, interspersed throughout the *Pinus ponderosa* series are highly productive mountain grasslands dominated by *Dathonia parryi*. Vegetation dominated by *Danthonia* is frequently found near the *Pinus ponderosa/Purshia tridentata* habitat type. Site differences between the two are highlighted not only by different cover vegetation and minor topographic variations, but by markedly different soils.

The *Danthonia parryi*-dominated vegetation is situated on a coarse, loamy, mature grassland soil, which has a high organic matter content ensuring favorable moisture relations within the rooting zone of the climax grass species. In contrast, the loamy skeletal soils, common to the *Pinus ponderosa/Purshia tridentata* habitat type, permits deeper infiltration of moisture to zones more coincident with the rooting habitat of both *Pinus ponderosa* and *Purshia tridentata*.

In the subalpine zone of the study area, coniferous forests, dominated by *Abies lasiocarpa* and *Picea engelmannii*, are the predominant climax vegetation types. Nevertheless, extensive high elevation dry grasslands, dominated by *Festuca thurberi*, can be found interspersed throughout the *Abies-Picea* forest in the northwestern and western portions of the Arapaho National Forest. The *Abies lasiocarpa/Carex geyeri* habitat type and the *Festuca*-dominated vegetation exemplify this landscape mosaic. Although sites representing both habitat types occupy similar topographic and spatial positions, edaphic differences between the two are conspicuous. Soils of the *Festuca*-dominated vegetation are by deep, fine loams. In contrast, the soils of the *Abies lasiocarpa/Carex geyeri* habitat type are fine to coarse loams, which lack the conspicuously high organic matter content characteristic of the soils under *Festuca*-dominated vegetation. The differential distribution of moisture in the rooting zones of the two, caused by edaphic differences, as well as the successful competition of grassland vegetation against tree seedling invasion, helps explain the presence and persistence of high elevation climax grasslands in a vegetational zone conventionally considered climax conifer forest.

## FURTHER STUDIES IN RELATION TO THE HABITAT TYPES

Several areas of research logically follow this study. The production of undergrowth vegetation in relation to habitat types needs to be examined. Ellison and Houston (1958) and Mueggler (1985b) have suggested that production of vegetation under *Populus tremuloides* could be used as an indicator of forage production and, therefore, range condition. In the Arapaho and Roosevelt National Forests, both cattle and sheep utilize, sometimes quite heavily, vegetation under *Populus*. It would be valuable to know the relationship between habitat types and potential undergrowth productivity.

The growth rates of important timber trees may correlate with habitat types similar to the relationship of growth rates of *Pinus ponderosa* and the habitat types in the northern Rocky Mountains described by Daubenmire (1961).

Numerous fungi attack *Populus tremuloides* in Colorado (Juzwik et al. 1978). Some *Populus* habitat types may be more susceptible to various species of fungi than others are. In northern Idaho and eastern Washington, *Arceuthobium* infects *Pinus ponderosa* in the *Pinus ponderosa/Agropyron spicatum* and *Pinus ponderosa/Purshia tridentata* habitat types but not in other habitat types dominated by *Pinus ponderosa* (Daubenmire 1961). Susceptibility of *Picea engelmannii* to insect infestation may be correlated with habitat types in Colorado (Shepherd 1959).

The relationship of forest habitat types and their successional stages to wildlife management also needs further research.

## LITERATURE CITED

Alexander, Robert R. 1966. Site indexes for lodgepole pine, with corrections or stand density: Instructions for field use. USDA Forest Service Research Paper RM–24, 7 p. Rocky Mountain Forest and Range Experimentation, Fort Collins, Colo.

Alexander, Robert R. 1967. Site indexes for Engelmann spruce in the central Rocky Mountains. USDA Forest Service Research Paper RM–31, 7 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Alexander, Robert R. 1974. Silviculture of subalpine forests in the central and southern Rocky Mountains: The status of our knowledge. USDA Forest Service Research Paper RM–121, 88 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Alexander, Robert R. 1977. Cutting methods in relation to resource use in Central Rocky Mountain spruce-fir forests. Journal of Forestry 5(8):395–400.

Alexander, Robert R. 1985. Major habitat types, community types, and plant communities in the Rocky Mountains. USDA Forest Service General Technical Report RM–123, 105 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Alexander, Robert R. 1986a. Silvicultural systems and cutting methods for old-growth spruce-fir forests in the central and southern Rocky Mountains. USDA Forest Service General Technical Report RM–126, 33 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Alexander, Robert R. 1986b. Silvicultural systems and cutting methods for old-growth lodgepole pine forests in the central Rocky Mountains. USDA Forest Service General Technical Report RM–127, 32 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Alexander, Robert R. 1986c. Silvicultural systems and cutting methds for ponderosa pine forests in the Front Range of the central Rocky Mountains. USDA Forest Service General Technical Report RM–128, 22 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Alexander, Robert R., and Carleton B. Edminster. 1980. Management of spruce-fir in even-aged stands in the central Rocky Mountains. USDA Forest Service Research Paper RM–217, 14 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Alexander, Robert R., and Carleton B. Edminster. 1981. Management of lodgepole pine in even-aged stands in the central Rocky Mountains. USDA Forest Service Research Paper RM–229, 11 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Arno, Stephen F., and Robert D. Pfister. 1977. Habitat types: An improved system for classifying Montana's forests. Western Wildlands 3(4):6–11.

Cayot, Linda J. 1978. Habitat preferences of the mountain cottontail. 42 p. M.S. thesis, Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins.

Chronic, J., and H. Chronic. 1972. Prairie peak and plateau. Colorado Geological Survey Bulletin 32, 126 p. Denver, Colo.

Clements, Frederick E. 1910. The life history of lodgepole burn forests. U.S. Department of Agriculture, Forest Service Bulletin 76, 56 p. Washington, D.C.

Daubenmire, R. 1943. Vegetational zonation in the Rocky Mountains. Botanical Review 9:325–393.

Daubenmire, R. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecological Monographs 22:301–330.

Daubenmire, R. 1961. Vegetative indicators of rate of height growth in ponderosa pine. Forest Science 7:24–34.

Daubenmire, R. 1968. Plant communities, a textbook of plant synecology. 300 p. Harper and Row, New York, N.Y.

Daubenmire, R. 1973. A comparison of approaches to the mapping of forest land for intensive management. Forest Chronicle 49:87–91.

Daubenmire, R. 1976. The use of vegetation in assessing the productivity of forest lands. Botanical Review 42:115–143.

Daubenmire, R., and Jean B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington Agriculture Experiment Station Technical Bulletin 60, 104 p. Pullman, Wash.

DeVelice, Robert L., John A. Ludwig, William H. Moir, and Frank Ronco, Jr. 1986. A classification of forest habitat types in northern New Mexico and southern Colorado. USDA Forest Service General Technical Report RM–000, 00 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. [In press]

Dix, Ralph L. 1974. Regional ecological systems of Colorado. p. 7–17. *In* Phillip O. Foss, compiler. Environment and Colorado. 197 p. Environmental Resources Center, Colorado State University, Fort Collins.

Ellison, Lincoln, and Walter R. Houston. 1958. Production of herbaceous vegetation in openings and under canopies of western aspen. Ecology 39:337–345.

George, R. D. 1920. The geology of the Ward region, Boulder County, Colorado. Colorado Geological Survey Bulletin 21, 74 p. Denver, Colo.

Haeffner, Arden D. 1971. Daily temperatures and precipitation for subalpine forests, Colorado. USDA Forest Service Research Paper RM–80, 48 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Harrington, H. D. 1954. Manual of the plants of Colorado. 666 p. Sage Books, Denver, Colo.

Hess, Karl. 1981. Phyto-edaphic study of habitat types of the Arapaho and Roosevelt National Forests. Ph.D. dissertation, 558 p, Department of Range Science, Colorado State University, Fort Collins.

Hoffman, George R., and Robert R. Alexander. 1976. Forest vegetation of the Bighorn Mountains, Wyoming: A habitat type classification. USDA Forest Service Research Paper RM–170, 38 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Hoffman, George R., and Robert R. Alexander. 1980. Forest vegetation of the Routt National Forest in northwestern Colorado: A habitat type classification. USDA Forest Service Research Paper RM–221, 39 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Hoffman, George R., and Robert R. Alexander. 1983. Forest vegetation of the White River National Forest in western Colorado: A habitat type classification. USDA Forest Service Research Paper RM–249, 36 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Jones, John R., and Norbert V. DeByle. 1985. Morphology. p. 11–18. *In* Aspen: Ecology and management in the western United States. Norbert V. DeByle and Robert P. Winokur, editors. USDA Forest Service General Technical Report RM–119, 283 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Juzwik, J., W. T. Nishijima, and T. E. Hinds. 1978. Survey of aspen cankers in Colorado. Plant Disease Reporter 62:906–910.

Layser, Earle F. 1974. Vegetative classification: Its application to forestry in the northern Rocky Mountains. Journal of Forestry 72:354–357.

Leaf, Charles F. 1975. Watershed management in the Rocky Mountain subalpine zone: The status of our knowledge. USDA Forest Service Research Paper RM–137, 31 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Leaf, Charles F., and Robert R. Alexander. 1975. Simulating timber yields and hydrologic imports resulting from timber harvest on subalpine watersheds. USDA Forest Service Research Paper RM–133, 20 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Lovering, T. S., and E. N. Goddard. 1950. Geology and ore deposits of the Front Range, Colorado. U.S. Geological Survey Professional Paper 223, 319 p. Denver, Colo.

Marr, John W. 1967. Ecosystems of the east slope of the Front Range in Colorado. University of Colorado Studies Series in Biology No. 8, 134 p. University of Colorado Press, Boulder.

Marr, John W. 1968a. Data on mountain environments II. Front Range, Colorado, four climax regions, 1953–1958. University of Colorado Studies Series in Biology No. 28, 171 p. University of Colorado Press, Boulder.

Marr, John W. 1968b. Data on mountain environments III. Front Range, Colorado, four climax regions, 1959–1964. University of Colorado Studies Series in Biology No. 29, 181 p. University of Colorado Press, Boulder.

Mason, David T. 1915. The life history of lodgepole pine in the Rocky Mountains. U.S. Department of Agriculture Bulletin 154, 35 p. Washington, D.C.

Mauk, Ronald L., and Jan A. Henderson. 1984. Forest habitat types of northern Utah. USDA Forest Service General Technical Report, INT–170, 89 p. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Moir, W. H. 1969. The lodgepole pine zone in Colorado. American Midland Naturalist 81:87–98.

Moir, William H., and John A. Ludwig. 1979. A classification of spruce-fir and mixed conifer habitat types of Arizona and New Mexico. USDA Forest Service Research Paper RM–207, 47 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Monsured, Robert A. 1984. Height, growth, and site index curves for inland Douglas-fir based on stem analysis data and forest habitat type. Forest Science 30:943–965.

Muegg!er, W. F. 1985a. Vegetation associations. p. 45–56. *In* Aspen: Ecology and management in the western United States. Norbert V. DeByle and Robert P. Winokur, editors. USDA Forest Service General Technical Report RM–119, 283 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Mueggler, W. F. 1985b. Forage. p. 129–134. *In* Aspen: Ecology and management in the western United States. Norbert V. DeByle and Robert P. Winokur, editors. USDA Forest Service General Technical Report RM–119, 283 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Mueggler, Walter F., and Robert B. Campbell. 1982. Aspen communty types on the Caribou and Targee National Forests in southwestern Idaho Idaho. USDA Forest Service Research Paper INT–294, 32 p. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Mueller-Dombois, O., and H. Ellenberg. 1974. Aims and methods of vegetation ecology. 547 p. John Wiley and Sons, Inc., New York, N.Y.

Mutel, C. F. 1976. From grassland to glacier: An ecology of Boulder County, Colorado. 168 p. Johnson Publishing Co., Boulder, Colo.

Peet, Robert K. 1978. Forest vegetation of the Colorado Front Range: Patterns of species diversity. Vegetatio 2:65–78.

Pfister, Robert D. 1972. Habitat type and regeneration. p. 120–125. *In* Permanent Association Committee proceedings, Western Forestry and Conservation Association. Portland, Oreg.

Pfister, Robert D., and Stephen F. Arno. 1980. Classifying forest haibtat types based on potential climax vegetation. Forest Science 26:52–70.

Pfister, Robert D., Bernard L. Kovalchik, Stephen F. Arno, and Richard C. Presby. 1977. Forest habitat types of Montana. USDA Forest Service General Technical Report INT–34, 174 p. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Ramaley, F. 1907. Plant zones in the Rocky Mountains of Colorado. Science 26:642–643.

Ramaley, F. 1909. The silva of Colorado. IV. Forest formations and forest trees of Colorado. University of Colorado Studies 6:249–281. Boulder.

Regelin, Wayne L., and Olof C. Wallmo. 1978. Duration of deer forage benefits after clearcut logging of subalpine forests in Colorado. USDA Forest Service Research Note RM–356, 4 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Robbins, W. W. 1910. Climatology and vegetation in Colorado. Botanical Gazette 49:256–280.

Rydberg, P. A. 1915. Phytogeographical notes on the Rocky Mountain region. IV. Forests of the subalpine and montane zones. Bulletin of the Torrey Botanical Club 42:11–25.

Rydberg, P. A. 1920. Phytogeographical notes on the Rocky Mountain region. IX. Wooded formations of the montane zone of the southern Rockies. Bulletin of the Torrey Botanical Club 47:441–454.

Schmid, J. M., and T. E. Hinds. 1974. Development of spruce-fir forests following spruce beetle outbreaks. USDA Forest Service Research Paper RM–131, 16 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Shepherd, R. F. 1959. Phytosociological and environmental characteristics of outbreak and non-outbreak areas of the two-year cycle spruce budworm, *Choristoneura fumiferana*. Ecology 40:608–619.

Steele, Robert, Stephen V. Cooper, David M. Ondov, and Robert D. Pfister. 1983. Forest habitat types of eastern Idaho-western Wyoming. USDA Forest Service General Technical Report INT–144, 122 p. Intermountain Forest and Range Experiment Station, and Intermountain Region, Ogden, Utah.

Steele, Robert, Robert D. Pfister, Russell A. Ryker, and Jay A. Kittams. 1981. Forest habitat types of central Idaho. USDA Forest Service General Technical Report INT–114, 138 p. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Tansley, A. G. 1935. The use and abuse of vegetational concepts and terms. Ecology 16:284–307.

Thornbury, W. D. 1965. Regional geomorphology of the United States. 609 p. John Wiley and Sons, New York, N.Y.

Troendle, Charles A., and James E. Meiman. 1984. Options for harvesting timber to control snowpack accumulation. p. 86–98. *In* Proceedings, 52nd Annual Meeting of the Western Snow Conference. [Sun Valley, Idaho, April 17–19, 1984]. Colorado State University, Fort Collins.

U.S. Department of Agriculture. 1951. Soil survey manual. U.S. Department of Agriculture Soil Conservation Service Handbook No. 18, 503 p. Washington, D.C.

U.S. Department of Agriculture. 1975. Soil taxonomy. U.S. Department of Agriculture Soil Conservation Service Handbook No. 436, 754 p. Washington, D.C.

Vanderwilt, J. W., F. M. Van Tuyl, W. O. Thompson, E. S. Shaw, P. G. Worcester. 1948. Guide to the geology of central Colorado. Colorado School of Mines Quarterly 43:1–176. Golden.

Wahlstom, E. E. 1947. Cenozoic physiographic history of the Front Range, Colorado. Bulletin of the Geological Society of America 58:551–572.

Wallmo, Olof C., Wayne L. Regelin, and Donald W. Reichert. 1972. Forage use by mule deer relative to logging in Colorado. Journal of Wildlife Management 36:1025–1033.

Weimer, R. J., and J. D. Haun. 1960. Guide to the geology of Colorado. Geological Society of America, Rocky Mountain Association of Geologists, Colorado Scientific Society. 310 p. Denver, Colo.

Youngblood, Andrew P., and Roland L. Mauk. 1985. Coniferous forest habitat types of central and southern Utah. USDA Forest Service General Technical Report INT–187, 89 p. Intermountain Forest and Range Experiment Station, Ogden, Utah.

Youngblood, Andrew P., and Walter F. Mueggler. 1981. Aspen community types on the Bridger-Teton National Forest in western Wyoming. USDA Forest Service Research Paper RM–272, 34 p. Intermountain Forest and Range Experiment Station, Ogden, Utah.

# APPENDIX

Table A-1.—Tree population for each habitat type. Numbers of trees listed are based on sample plot data of 375 m² per stand.

| Habitat type and species | Stands sampled | Mean basal area | Seedling/height dm 0-6 | t-24 | 24+ | Diameter (b.h.) classes in dm 1-2 | 2-3 | 3-4 | 4-5 | 5-6 | 6-7 | 7-8 | 8+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number | m²/ha | Mean number of trees/stand | | | | | | | | | | |
| *Juniperus scopulorum/Cercocarpus montanus* | 4 | 4.8 | | | | | | | | | | | |
| *Juniperus scopulorum* | | | 6 | 11 | 10 | 4 | 1 | + | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | 0 | 0 | +[1] | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | 1 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum/Purshia tridentata* | 4 | 4.8 | | | | | | | | | | | |
| *Juniperus scopulorum* | | | 3 | 8 | 6 | 6 | 1 | + | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | + | 0 | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | 1 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum/Artemisia tridentata* | 4 | 4.8 | | | | | | | | | | | |
| *Juniperus scopulorum* | | | 2 | 5 | 6 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | + | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa/Cercocarpus montanus* | 4 | 20.2 | | | | | | | | | | | |
| *Pinus ponderosa* | | | 2 | 2 | 1 | 5 | 6 | 4 | + | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa/Purshia tridentata* | 4 | 26.9 | | | | | | | | | | | |
| *Pinus ponderosa* | | | 1 | 2 | 4 | 8 | 5 | 4 | 1 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | + | + | + | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa/Muhlenbergia montana* | 4 | 18.4 | | | | | | | | | | | |
| *Pinus ponderosa* | | | 1 | 3 | 3 | 4 | 3 | 2 | + | + | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | + | 1 | 1 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus flexilis* | | | 0 | 0 | 1 | + | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | 2 | + | 2 | 1 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa/Carex rossii* | 5 | 36.3 | | | | | | | | | | | |
| *Pinus ponderosa* | | | 3 | 12 | 18 | 22 | 13 | 3 | 0 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | 0 | 1 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa/Hesperochloa kingii* | 4 | 39.0 | | | | | | | | | | | |
| *Pinus ponderosa* | | | 1 | 6 | 7 | 6 | 6 | 6 | 2 | 1 | 0 | 0 | 0 |
| *Pinus flexilis* | | | 1 | 1 | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | 1 | + | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii/Carex rossii* | 4 | 28.5 | | | | | | | | | | | |
| *Pseudotsuga menziesii* | | | 383 | 170 | 23 | 11 | 8 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | 2 | 8 | 17 | 9 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | 0 | 2 | 8 | 1 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii/Carex geyeri* | 4 | 33.1 | | | | | | | | | | | |
| *Pseudotsuga menziesii* | | | 20 | 7 | 10 | 22 | 13 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | 1 | + | 1 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii/Physocarpus monogynus* | 4 | 30.3 | | | | | | | | | | | |
| *Pseudotsuga menziesii* | | | 101 | 38 | 11 | 12 | 6 | 3 | + | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | 0 | 0 | 2 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | 6 | 10 | 2 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta* | | | 0 | 0 | 0 | 1 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii/Jamesia americana* | 4 | 40.2 | | | | | | | | | | | |
| *Pseudotsuga menziesii* | | | 182 | 58 | 40 | 12 | 8 | 4 | 1 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | 0 | 2 | 13 | 3 | 3 | 1 | + | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | 4 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Populus angustifolia/Salix exigua* | 4 | 44.5 | | | | | | | | | | | |
| *Populus angustifolia* | | | 4 | 7 | 11 | 14 | 12 | 6 | 1 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | + | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | 0 | 0 | + | + | + | 0 | 0 | + | 0 | 0 | 0 |
| *Populus tremuloides* | | | + | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Picea pungens* | | | 0 | 0 | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Picea pungens/Arnica cordifolia* | 4 | 65.7 | | | | | | | | | | | |
| *Picea pungens* | | | 59 | 25 | 27 | 8 | 6 | 3 | 1 | 1 | 1 | + | + |
| *Pseudotsuga menziesii* | | | + | 1 | 1 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides* | | | 17 | 20 | 4 | 6 | 3 | 2 | + | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | 0 | 0 | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta* | | | 1 | 0 | 0 | 1 | 1 | + | 0 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa* | | | 36 | 26 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus flexilis/Juniperus communis* | 4 | 28.0 | | | | | | | | | | | |
| *Pinus flexilis* | | | 7 | 8 | 10 | 10 | 6 | 2 | 0 | + | 0 | 0 | 0 |
| *Pinus ponderosa* | | | + | + | 1 | + | 1 | + | 0 | + | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | + | + | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides* | | | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta* | | | 1 | 3 | 2 | 1 | 1 | 1 | 0 | + | 0 | 0 | 0 |
| *Abies lasiocarpa* | | | + | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pinus flexilis/Calamagrostis purpurascens* | 4 | 25.0 | | | | | | | | | | | |
| *Pinus flexilis* | | | 8 | 11 | 5 | 8 | 7 | 4 | + | 0 | 0 | 0 | 0 |
| *Pinus contorta* | | | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | + | 0 | 1 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus flexilis/Trifolium dasyphyllum* | 4 | 46.4 | | | | | | | | | | | |
| *Pinus flexilis* | | | 3 | 3 | 2 | 12 | 15 | 6 | 1 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa* | | | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | 1 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta/Juniperus communis* | 4 | 33.8 | | | | | | | | | | | |
| *Pinus contorta* | | | 4 | 6 | 12 | 28 | 9 | 3 | 0 | 0 | 0 | 0 | 0 |
| *Pinus ponderosa* | | | 0 | + | + | + | 0 | + | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | + | 0 | + | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides* | | | 7 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus flexilis* | | | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta/Carex geyeri* | 4 | 42.7 | | | | | | | | | | | |
| *Pinus contorta* | | | 27 | 8 | 8 | 33 | 16 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides* | | | 3 | 4 | 2 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | 1 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta/Shepherdia canadensis* | 5 | 27.2 | | | | | | | | | | | |
| *Pinus contorta* | | | 28 | 24 | 18 | 19 | 10 | 3 | + | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | + | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides* | | | 7 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | + | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa* | | | + | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta/Vaccinium scoparium* | 4 | 44.3 | | | | | | | | | | | |
| *Pinus contorta* | | | 8 | 11 | 20 | 24 | 13 | 4 | 1 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | 1 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa* | | | 1 | 2 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides/Festuca thurberi* | 4 | 49.4 | | | | | | | | | | | |
| *Populus tremuloides* | | | 10 | 8 | 17 | 49 | 13 | 4 | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides/Carex geyeri* | 4 | 47.1 | | | | | | | | | | | |
| *Populus tremuloides* | | | 36 | 30 | 16 | 68 | 9 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Juniperus scopulorum* | | | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | | | 0 | 0 | 0 | + | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus flexilis* | | | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta* | | | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides/Thalictrum fendleri* | 4 | 52.1 | | | | | | | | | | | |
| *Populus tremuloides* | | | 14 | 20 | 30 | 38 | 18 | 3 | + | 0 | 0 | 0 | 0 |
| *Pinus flexilis* | | | + | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta* | | | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa* | | | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii/Trifolium dasyphyllum* | 4 | 49.8 | | | | | | | | | | | |
| *Picea engelmannii* | | | 24 | 20 | 34 | 34 | 12 | 4 | 1 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa* | | | 2 | + | + | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus aristata* | | | 0 | 0 | 2 | 4 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa/Carex geyeri* | 4 | 58.5 | | | | | | | | | | | |
| *Abies lasiocarpa* | | | 86 | 45 | 6 | 15 | 4 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | 26 | 25 | 12 | 9 | 6 | 4 | 1 | + | + | 0 | + |
| *Populus tremuloides* | | | 11 | 6 | 0 | + | + | + | 0 | 0 | 0 | 0 | 0 |
| *Pinus contorta* | | | 0 | 0 | 0 | 6 | 3 | 4 | + | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa/Vaccinium scoparium* | 5 | 61.6 | | | | | | | | | | | |
| *Abies lasiocarpa* | | | 94 | 85 | 23 | 6 | 3 | 1 | + | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | 83 | 55 | 24 | 17 | 9 | 5 | 2 | 1 | + | 0 | 0 |
| *Pinus contorta* | | | 0 | 0 | 0 | 0 | + | 0 | 0 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa/Senecio triangularis* | 4 | 59.9 | | | | | | | | | | | |
| *Abies lasiocarpa* | | | 71 | 51 | 31 | 11 | 4 | + | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | 54 | 49 | 37 | 13 | 18 | 6 | 2 | + | + | 0 | 0 |
| *Pinus contorta* | | | 1 | + | 1 | 1 | 1 | + | 0 | 0 | 0 | 0 | 0 |
| *Abies lasiocarpa/Calamagrostis canadensis* | 4 | 49.8 | | | | | | | | | | | |
| *Abies lasiocarpa* | | | 56 | 45 | 41 | 6 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Picea engelmannii* | | | 74 | 80 | 48 | 10 | 6 | 4 | 3 | + | + | 0 | 0 |
| *Populus tremuloides* | | | 2 | 6 | 9 | 2 | + | + | 0 | 0 | 0 | 0 | 0 |
| *Pinus aristata/Trifolium dasyphyllum* | 4 | 61.1 | | | | | | | | | | | |
| *Pinus aristata* | | | 1 | 1 | + | 8 | 9 | 8 | 2 | + | 0 | 0 | + |
| *Picea engelmannii* | | | + | 1 | 1 | 3 | 1 | 1 | + | 0 | 0 | 0 | 0 |

[1]*Species with less than 1 tree per d.b.h. class.*

Table A-2.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Juniperus scopulorum/Cercocarpus montanus*, *J. scopulorum/Purshia tridentata*, and *J. scopulorum/Artemisia tridentata* habitat types.

| Species | *Juniperus/ Cercocarpus* (4 stands) | *Juniperus/ Purshia* (4 stands) | *Juniperus/ Artemisia* (4 stands) |
|---|---|---|---|
| Medium Shrubs | | | |
| *Artemisia tridentata* | — | — | 100/21 |
| *Cercocarpus montanus* | 100/20 | 25/ + | — |
| *Chrysothamnus nauseosus* | 50/ + [1] | — | — |
| *Physocarpus monogynus* | 50/ + | — | — |
| *Purshia tridentata* | 50/2 | 100/19 | 50/2 |
| *Rhus trilobata* | 50/2 | 50/1 | — |
| *Ribes cereum* | 75/1 | 50/1 | 100/1 |
| *Rubus deliciosus* | 75/1 | 100/1 | — |
| Low Shrubs | | | |
| *Artemisia frigida* | 100/1 | 100/1 | 100/1 |
| *Leptodactylon pungens* | — | 100/ + | 100/1 |
| *Opuntia polyacantha* | 100/1 | 100/2 | 100/1 |
| Graminoids | | | |
| *Agropyron griffithsii* | 100/2 | 100/3 | 25/ + |
| *Bouteloua gracilis* | 75/3 | 75/3 | 75/1 |
| *Carex petasata* | 50/ + | — | — |
| *Carex rossii* | 50/2 | 100/4 | 75/2 |
| *Elymus ambiguus* | 50/ + | 75/1 | 100/4 |
| *Hesperochloa kingii* | 50/ + | 75/1 | — |
| *Koeleria cristata* | 25/ + | 75/ + | 25/ + |
| *Muhlenbergia filiculmis* | 25/ + | 75/ + | 25/ + |
| *Muhlenbergia montana* | 25/ + | 100/1 | 50/1 |
| *Oryzopsis hymenoides* | — | 25/ + | 100/1 |
| *Oryzopsis micrantha* | — | — | 75/2 |
| *Poa compressa* | 50/ + | — | — |
| *Poa fendleriana* | 50/ + | 50/ + | 50/ + |
| *Poa sandbergii* | 100/1 | 75/1 | 25/ + |
| *Sitanion hystrix* | — | 25/ + | 50/ + |
| *Stipa comata* | 100/2 | 100/3 | 75/2 |
| *Stipa viridula* | 50/ + | — | — |
| Forbs | | | |
| *Achillea lanulosa* | 100/ + | 75/ + | 25/ + |
| *Allium textile* | 100/ + | — | — |
| *Anaphalis margaritacea* | 50/ + | — | — |
| *Antennaria rosea* | 50/ + | 50/ + | — |
| *Artemisia ludoviciana* | 50/ + | 100/1 | 50/ + |
| *Astragalus flexuosus* | — | 50/ + | — |
| *Campanula rotundifolia* | 75/ + | — | — |
| *Cerastium arvense* | 50/ + | — | — |
| *Chrysopsis villosa* | 25/ + | 100/1 | 25/ + |
| *Cryptantha virgata* | 25/ + | 50/ + | 25/ + |
| *Cystopteris fragilis* | 75/ + | 75/ + | 50/ + |
| *Delphinium nelsonii* | 50/ + | — | — |
| *Eriogonum flavum* | 50/ + | — | — |
| *Eriogonum umbellatum* | 75/1 | 100/1 | 75/ + |
| *Erysimum asperum* | 75/ + | 50/ + | 25/ + |
| *Gaillardia aristata* | — | 50/ + | — |
| *Harbouria trachypleura* | 50/ + | 25/ + | — |
| *Helianthus pumilus* | 75/1 | 100/3 | — |
| *Heuchera bracteata* | 100/1 | 75/ + | 25/ + |
| *Lesquerella montana* | 50/ + | 75/1 | — |
| *Lomatium orientale* | 75/ + | — | — |
| *Mertensia lanceolata* | 75/1 | — | 25/ + |
| *Penstemon virens* | 100/1 | 75/1 | 75/1 |
| *Phacelia heterophylla* | 25/ + | 75/ + | — |
| *Potentilla fissa* | 100/2 | 100/2 | 75/1 |
| *Pulsatilla ludoviciana* | 75/1 | 25/ + | — |
| *Scutellaria brittonii* | 25/ + | 50/ + | 25/ + |
| *Sedum stenopetalum* | 75/ + | 25/ + | — |
| *Senecio fendleri* | — | 50/ + | 50/ + |
| *Senecio integerrimus* | 50/ + | 25/ + | 25/ + |

[1]*Coverage of less than 0.5%.*

Table A-3.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Pinus ponderosa/Cercocarpus montanus*, *P. ponderosa/Purshia tridentata*, *P. ponderosa/Muhlenbergia montana*, *P. ponderosa/Carex rossii*, and *P. ponderosa/Hesperochloa kingii*.

| Species | *Pinus/ Cercocarpus* (4 stands) | *Pinus/ Purshia* (4 stands) | *Pinus/ Muhlenbergia* (4 stands) | *Pinus/ Carex* (5 stands) | *Pinus/ Hesperochloa* (4 stands) |
|---|---|---|---|---|---|
| Medium Shrubs | | | | | |
| *Cercocarpus montanus* | 100/14 | — | — | 80/+ [1] | — |
| *Juniperus communis* | — | 50/3 | 50/1 | 80/1 | 50/1 |
| *Prunus virginiana* | 50/1 | — | 25/+ | — | — |
| *Purshia tridentata* | — | 100/24 | 25/+ | — | 25/+ |
| *Rhus trilobata* | 25/+ | — | 50/+ | — | — |
| *Ribes cereum* | 50/1 | 75/+ | 100/1 | 40/+ | 100/3 |
| *Rubus deliciosus* | 25/+ | 25/+ | 75/+ | — | — |
| Low Shrubs | | | | | |
| *Arctostaphylos uva-ursi* | — | 50/2 | 25/+ | 20/+ | 25/+ |
| *Artemisia frigida* | 100/1 | 75/1 | 100/1 | 60/+ | 75/+ |
| *Ceanothus fendleri* | 50/+ | — | 50/1 | 20/+ | — |
| *Opuntia polyacantha* | 100/+ | — | 75/+ | 40/+ | — |
| *Rosa woodsii* | 25/+ | — | 25/+ | 40/+ | 25/+ |
| *Yucca glauca* | 50/+ | — | 50/+ | 20/+ | — |
| Graminoids | | | | | |
| *Agropyron griffithsii* | 100/1 | 50/+ | 100/2 | 40/+ | 25/+ |
| *Bouteloua gracilis* | 75/1 | 25/+ | 50/+ | — | — |
| *Carex geyeri* | — | 50/+ | — | 20/+ | 50/+ |
| *Carex heliophila* | — | 75/1 | 25/+ | — | — |
| *Carex rossii* | 100/4 | 100/2 | 50/+ | 100/10 | 50/1 |
| *Festuca idahoensis* | — | 25/+ | 50/+ | — | 25/+ |
| *Hesperochloa kingii* | 25/+ | 75/+ | 75/+ | 60/1 | 100/10 |
| *Koeleria cristata* | 100/+ | 75/1 | 25/+ | 60/+ | 75/+ |
| *Muhlenbergia filiculmis* | — | 50/+ | 75/1 | — | — |
| *Muhlenbergia montana* | 75/2 | 100/2 | 100/11 | 100/+ | 25/+ |
| *Poa fendleriana* | 25/+ | 50/+ | 25/+ | 40/+ | — |
| *Poa sandbergii* | — | 50/+ | 50/+ | — | — |
| *Stipa comata* | 100/1 | 25/+ | 50/+ | 40/+ | — |
| Forbs | | | | | |
| *Achillea lanulosa* | — | 75/+ | 100/+ | 40/+ | 75/+ |
| *Allium geyeri* | — | 50/+ | 75/+ | — | 100/+ |
| *Allium textile* | 100/+ | 25/+ | — | 60/+ | — |
| *Antennaria rosea* | — | 75/+ | — | 60/+ | 25/+ |
| *Arenaria fendleri* | — | 50/+ | — | — | 25/+ |
| *Artemisia ludoviciana* | 100/1 | 75/+ | 75/+ | 40/+ | 75/+ |
| *Astragalus flexuosus* | — | 25/+ | 50/+ | — | — |
| *Campanula rotundifolia* | 50/+ | 25/+ | 50/+ | 40/1 | 75/+ |
| *Chrysopsis villosa* | 75/1 | 75/+ | 100/2 | 20/+ | 25/+ |
| *Cryptantha virgata* | 50/+ | 25/+ | — | 20/+ | — |
| *Cystopteris fragilis* | 100/+ | 75/+ | — | 20/+ | — |
| *Eriogonum umbellatum* | 100/1 | 75/+ | 100/1 | — | 25/+ |
| *Erysimum asperum* | 75/1 | 75/+ | 75/+ | 40/+ | 25/+ |
| *Euphorbia robusta* | 25/+ | 50/+ | 50/+ | — | 25/+ |
| *Geranium fremontii* | 100/1 | 100/+ | 100/1 | 60/+ | 100/1 |
| *Harbouria trachypleura* | 75/+ | 75/+ | 75/+ | 80/+ | 100/1 |
| *Helianthus pumilus* | 50/+ | 25/+ | 75/+ | 20/+ | — |
| *Lesquerella montana* | 75/1 | 50/+ | 50/+ | 20/+ | 25/+ |
| *Leucocrinum montanum* | 100/+ | 25/+ | 50/+ | 20/+ | 25/+ |
| *Mertensia lanceolata* | 25/+ | 75/+ | 25/+ | 100/+ | 75/+ |
| *Penstemon virens* | 50/+ | 100/1 | 50/+ | 60/+ | 75/+ |
| *Phacelia heterophylla* | 75/+ | 75/+ | 75/+ | 40/+ | — |
| *Potentilla fissa* | 50/+ | 75/1 | 50/+ | 40/+ | 75/+ |
| *Potentilla hippiana* | — | 25/+ | 25/+ | — | 50/+ |
| *Pulsatilla ludoviciana* | — | 25/+ | — | 40/+ | 50/+ |
| *Scutellaria brittonii* | 75/+ | 25/+ | 75/+ | — | — |
| *Sedum stenopetalum* | — | 75/+ | 75/1 | 20/+ | 100/+ |
| *Senecio fendleri* | — | 25/+ | 50/+ | 60/+ | 75/+ |

[1]*Coverage less than 0.5%.*

Table A-4.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Pseudotsuga menziesii/Carex rossii, P. menziesii/Physocarpus monogynus, P. menziesii/ Jamesia americana*, and *P. menziesii/Carex geyeri*.

| Species | *Pseudotsuga/ Carex r.* (4 stands) | *Pseudotsuga/ Physocarpus* (4 stands) | *Pseudotsuga/ Jamesia* (4 stands) | *Pseudotsuga/ Carex g.* (4 stands) |
|---|---|---|---|---|
| Tall Shrubs | | | | |
| *Acer glabrum* | — | 50/+ | 75/1 | 75/+[1] |
| Medium Shrubs | | | | |
| *Jamesia americana* | — | 100/3 | 100/22 | — |
| *Juniperus communis* | 75/1 | 50/1 | 100/7 | 50/1 |
| *Shepherdia canadensis* | — | 25/+ | 50/1 | — |
| Low Shrubs | | | | |
| *Amelanchier alnifolia* | — | 25/+ | — | 50/+ |
| *Arctostaphylos uva-ursi* | — | — | 50/+ | — |
| *Berberis repens* | — | — | — | 75/+ |
| *Pachistima myrsinites* | — | — | — | 100/1 |
| *Physocarpus monogynus* | 100/1 | 100/20 | 100/7 | 50/1 |
| *Rosa woodsii* | — | 25/+ | — | 100/1 |
| *Symphoricarpos albus* | 50/+ | 50/+ | 50/+ | — |
| *Symphoricarpos oreophilus* | — | — | — | 100/4 |
| Graminoids | | | | |
| *Agropyron griffithsii* | 75/1 | 25/+ | — | — |
| *Carex geyeri* | 25/+ | — | — | 100/35 |
| *Carex rossii* | 100/5 | 50/+ | 75/+ | 25/+ |
| *Festuca idahoensis* | — | 25/+ | — | 50/+ |
| *Hesperochloa kingii* | 75/1 | 75/2 | 50/+ | — |
| *Koeleria cristata* | 75/+ | 25/+ | 25/+ | 50/+ |
| *Muhlenbergia montana* | 50/+ | — | — | — |
| *Poa fendleriana* | — | — | — | 50/1 |
| *Poa interior* | — | — | 50/+ | 100/+ |
| *Poa pratensis* | 75/+ | 50/+ | 50/+ | — |
| *Stipa columbiana* | — | — | — | 50/+ |
| Forbs | | | | |
| *Achillea lanulosa* | 100/1 | 75/+ | 25/+ | 75/+ |
| *Allium textile* | 50/+ | 50/+ | — | — |
| *Anaphalis margaritacea* | 50/+ | 25/+ | 75/+ | 100/+ |
| *Androsace septentrionalis* | 75/+ | — | 25/+ | — |
| *Arnica cordifolia* | — | 25/+ | 50/+ | 50/+ |
| *Artemisia ludoviciana* | 100/+ | — | — | — |
| *Astragalus flexuosus* | — | 25/+ | — | 100/1 |
| *Campanula rotundifolia* | 100/1 | 75/+ | 25/+ | 25/+ |
| *Cerastium arvense* | 50/+ | 25/+ | — | — |
| *Clematis occidentalis* | — | 50/+ | 50/+ | 100/2 |
| *Cystopteris fragilis* | 100/+ | 75/+ | 75/+ | — |
| *Delphinium nelsonii* | 50/+ | 75/+ | — | — |
| *Erigeron glabellus* | — | — | — | — |
| *Erigeron speciosus* | — | — | — | 75/+ |
| *Erysimum asperum* | 50/+ | — | — | — |
| *Fragaria ovalis* | — | 50/+ | 100/+ | 100/1 |
| *Frasera speciosa* | — | — | 50/+ | — |
| *Galium boreale* | 50/+ | 75/+ | 50/+ | 100/+ |
| *Geranium fremontii* | 75/+ | 75/+ | 25/+ | — |
| *Heuchera bracteata* | 100/+ | 50/+ | 75/+ | — |
| *Mertensia bakeri* | — | — | — | 50/+ |
| *Penstemon virens* | 50/1 | 25/+ | 25/+ | — |
| *Potentilla fissa* | 50/+ | 75/1 | 100/1 | — |
| *Pulsatilla ludoviciana* | 100/+ | 25/+ | 25/+ | 50/+ |
| *Saxifraga bronchialis* | — | 25/+ | 100/1 | — |
| *Saxifraga rhomboidea* | 100/+ | 50/+ | — | — |
| *Sedum stenopetalum* | 75/+ | 25/+ | 25/+ | — |
| *Smilacina stellata* | — | — | — | 50/1 |

[1]*Coverage less than 0.5%.*

Table A-5.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Populus tremuloides/Festuca thurberi*, *P. tremuloides/Carex geyeri*, and *P. tremuloides/Thalictrum fendleri*.

| Species | *Populus/ Festuca* (4 stands) | *Populus/ Carex* (4 stands) | *Populus/ Thalictrum* (4 stands) |
|---|---|---|---|
| Medium Shrubs | | | |
| *Amelanchier alnifolia* | 50/+[1] | 25/+ | — |
| *Artemisia tridentata* | 75/+ | 25/+ | — |
| *Juniperus communis* | 25/+ | 100/3 | 50/1 |
| Low Shrubs | | | |
| *Berberis repens* | — | 100/10 | 25/+ |
| *Rosa woodsii* | 75/2 | 100/3 | 50/2 |
| *Symphoricarpos oreophilus* | 100/6 | — | 25/+ |
| Graminoids | | | |
| *Agropyron trachycaulum* | 100/1 | 75/+ | 100/1 |
| *Bromus anomalus* | 100/+ | 100/1 | 100/1 |
| *Bromus marginatus* | 25/+ | 75/+ | 75/1 |
| *Carex geyeri* | 75/9 | 100/34 | 100/24 |
| *Elymus glaucus* | 25/+ | 75/1 | 75/1 |
| *Festuca thurberi* | 100/41 | — | — |
| *Poa ampla* | 50/+ | — | — |
| *Poa interior* | 100/1 | 75/+ | 75/+ |
| *Poa pratensis* | 25/+ | 25/+ | 50/+ |
| *Stipa columbiana* | 75/1 | 50/+ | 25/+ |
| Forbs | | | |
| *Achillea lanulosa* | 100/2 | 100/1 | 50/+ |
| *Allium geyeri* | 50/+ | — | — |
| *Aquilegia caerulea* | 25/+ | 50/1 | 75/+ |
| *Arnica cordifolia* | — | 100/2 | 50/+ |
| *Astragalus miser* | 50/+ | — | — |
| *Calochortus gunnisonii* | 50/+ | — | — |
| *Campanula rotundifolia* | 75/+ | 50/+ | — |
| *Epilobium angustifolium* | 25/+ | — | 75/1 |
| *Erigeron speciosus* | 100/1 | 25/+ | — |
| *Fragaria ovalis* | — | 50/+ | 25/+ |
| *Galium boreale* | 75/1 | 100/1 | 75/1 |
| *Geranium richardsonii* | 50/+ | 25/+ | 100/11 |
| *Lathyrus leucanthus* | 100/9 | 75/8 | 75/8 |
| *Ligusticum porteri* | 25/+ | 100/1 | 100/34 |
| *Lupinus argenteus* | 25/+ | — | 50/1 |
| *Mertensia ciliata* | — | — | 50/1 |
| *Osmorhiza depauperata* | — | 50/3 | 100/1 |
| *Senecio serra* | — | — | 50/1 |
| *Smilacina stellata* | 25/+ | — | 75/1 |
| *Solidago* spp. | — | 50/+ | 25/+ |
| *Taraxacum officinale* | 50/1 | 50/+ | 100/1 |
| *Thalictrum fendleri* | 75/1 | 50/1 | 100/25 |
| *Thermopsis divaricarpa* | 25/+ | 50/+ | — |
| *Vicia americana* | 100/3 | 25/+ | 25/+ |

[1]*Coverage less than 0.5%.*

Table A-6.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Pinus flexilis/Juniperus communis*, *P. flexilis/Calamagrostis purpurascens*, and *P. flexilis/Trifolium dasyphyllum*.

| Species | *Pinus/ Juniperus* (4 stands) | *Pinus/ Calamagrostis* (4 stands) | *Pinus/ Trifolium* (4 stands) |
|---|---|---|---|
| Medium Shrubs | | | |
| *Juniperus communis* | 100/17 | — | 100/1 |
| *Potentilla fruticosa* | — | — | 75/ +[1] |
| *Ribes cereum* | 50/ + | — | — |
| *Ribes montigenum* | — | — | 50/ + |
| Low Shrubs | | | |
| *Arctostaphylos uva-ursi* | 75/5 | — | — |
| *Rosa woodsii* | 50/2 | — | — |
| Graminoids | | | |
| *Agropyron scribneri* | — | — | 75/1 |
| *Calamagrostis purpurascens* | 75/1 | 100/11 | 100/1 |
| *Carex elynoides* | — | — | 75/1 |
| *Carex foenea* | — | 25/ + | 100/1 |
| *Carex rossii* | 100/1 | 75/ + | 50/1 |
| *Carex rupestris* | — | — | 50/ + |
| *Festuca brachyphylla* | — | 25/ + | 100/1 |
| *Poa*spp. | — | — | 50/ + |
| *Poa arctica* | — | — | 50/ + |
| *Poa interior* | 50/ + | 25/ + | 25/ + |
| *Poa lettermani* | — | — | 50/ + |
| *Poa pattersoni* | — | — | 50/ + |
| *Poa rupicola* | — | 75/ + | 25/ + |
| *Poa sandbergii* | 25/ + | — | 50/ + |
| *Trisetum spicatum* | — | — | 50/ + |
| Forbs | | | |
| *Achillea lanulosa* | — | — | 100/ + |
| *Antennaria parvifolia* | — | 50/ + | 100/ + |
| *Arenaria fendleri* | 75/ + | 100/2 | 100/2 |
| *Arenaria obtusiloba* | — | 50/1 | 25/ + |
| *Artemisia scopulorum* | — | — | 50/ + |
| *Campanula rotundifolia* | — | 25/ + | 100/ + |
| *Chrysopsis villosa* | 25/ + | — | 75/ + |
| *Draba streptocarpa* | 75/ + | — | 50/ + |
| *Erigeron compositus* | 75/ + | 75/ + | — |
| *Erigeron pinnatisectus* | — | 100/1 | 50/ + |
| *Erysimum nivale* | — | — | 50/ + |
| *Frasera speciosa* | 50/ + | 75/ + | — |
| *Geranium fremontii* | 75/ + | — | — |
| *Geum rossii* | — | 50/ + | 75/1 |
| *Harbouria trachypleura* | 75/ + | 25/ + | — |
| *Heuchera parvifolia* | — | — | 75/ + |
| *Hymenoxys acaulis* | 25/ + | — | 50/ + |
| *Hymenoxys grandiflora* | — | — | 50/ + |
| *Lupinus argenteus* | — | 75/1 | — |
| *Mertensia viridis* | — | — | 100/2 |
| *Oreoxis alpina* | — | — | 100/1 |
| *Penstemon virens* | 75/ + | — | — |
| *Penstemon whippleanus* | — | — | 75/ + |
| *Polemonium delicatum* | — | — | 75/1 |
| *Polygonum bistortoides* | — | — | 50/ + |
| *Potentilla diversifolia* | 25/ + | — | 50/ + |
| *Potentilla fissa* | 75/ + | — | — |
| *Potentilla hippiana* | 25/ + | — | 50/1 |
| *Potentilla pulcherrima* | — | 75/ + | — |
| *Potentilla subviscosa* | — | — | 50/ + |
| *Pulsatilla ludoviciana* | 50/ + | 100/1 | 75/ + |
| *Saxifraga bronchialis* | 25/ + | 50/1 | 75/1 |
| *Sedum stenopetalum* | 100/ + | 75/1 | 100/1 |
| *Solidago ciliosa* | 50/ + | 25/ + | — |
| *Thlaspi alpestre* | — | — | 50/ + |
| *Thermopsis divaricarpa* | 75/ + | — | — |
| *Trifolium dasyphyllum* | — | — | 100/32 |

[1]*Coverage less than 0.5%.*

Table A-7.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Pinus contorta/Juniperus communis*, *P. contorta/Carex geyeri*, *P. contorta/Shepherdia canadensis*, and *P. contorta/Vaccinium scoparium*.

| Species | *Pinus/ Juniperus* (4 stands) | *Pinus/ Carex* (4 stands) | *Pinus/ Shepherdia* (5 stands) | *Pinus/ Vaccinium* (4 stands) |
|---|---|---|---|---|
| Medium Shrubs | | | | |
| *Juniperus communis* | 100/12 | 100/2 | 80/6 | 100/3 |
| *Shepherdia canadensis* | 25/+[1] | 50/+ | 100/42 | 25/1 |
| Low Shrubs | | | | |
| *Arctostaphylos uva-ursi* | 100/2 | 50/4 | 80/1 | 25/+ |
| *Berberis repens* | 25/+ | 75/+ | 100/1 | 50/+ |
| *Pachistima myrsinites* | — | 50/1 | 40/4 | — |
| *Rosa woodsii* | 75/+ | 100/2 | 100/3 | 75/+ |
| *Vaccinium caespitosum* | — | 50/5 | — | — |
| *Vaccinium myrtillus* | — | — | 40/2 | — |
| *Vaccinium scoparium* | 25/+ | 25/+ | 100/27 | 100/37 |
| Graminoids | | | | |
| *Agropyron trachycaulum* | — | 50/+ | — | — |
| *Bromus anomalus* | 25/+ | 50/+ | 20/+ | — |
| *Calamagrostis canadensis* | — | 50/+ | — | — |
| *Calamagrostis purpurascens* | 50/+ | — | — | — |
| *Carex aurea* | 50/+ | — | — | 25/+ |
| *Carex geyeri* | 25/+ | 100/33 | 60/+ | 25/+ |
| *Carex rossii* | 50/+ | 25/+ | 80/1 | 50/+ |
| *Elymus glaucus* | — | 50/+ | — | — |
| *Poa interior* | 50/+ | 75/+ | 20/+ | — |
| *Trisetum spicatum* | 25/+ | 50/+ | 40/+ | — |
| Forbs | | | | |
| *Achillea lanulosa* | 25/+ | 75/1 | 20/+ | 25/+ |
| *Antennaria rosea* | 25/+ | — | 40/+ | — |
| *Aquilegia caerulea* | — | 50/+ | — | — |
| *Arnica cordifolia* | 75/1 | 100/2 | 100/1 | 50/+ |
| *Astragalus miser* | — | 75/3 | — | — |
| *Campanula rotundifolia* | 25/+ | 75/+ | 20/+ | 25/+ |
| *Castilleja septentrionalis* | — | 50/+ | — | — |
| *Epilobium angustifolium* | 50/+ | 100/+ | 80/+ | 50/+ |
| *Fragaria ovalis* | 25/+ | 50/1 | 40/+ | — |
| *Galium boreale* | — | 50/+ | 20/+ | — |
| *Geranium fremontii* | 50/+ | — | — | — |
| *Haplopappus parryi* | 50/+ | 75/+ | 80/+ | — |
| *Harbouria trachypleura* | 50/+ | — | — | — |
| *Lathyrus leucanthus* | 25/+ | 75/1 | — | — |
| *Lupinus argenteus* | 25/+ | 75/1 | 20/+ | 50/1 |
| *Penstemon virens* | 75/+ | — | — | — |
| *Potentilla fissa* | 75/1 | — | — | — |
| *Pseudocymopterus montanus* | — | 50/+ | — | — |
| *Pyrola chlorantha* | — | 50/+ | 80/+ | — |
| *Sedum stenopetalum* | 75/+ | — | — | 25/+ |
| *Senecio fendleri* | 50/+ | — | — | — |
| *Solidago ciliosa* | 25/+ | 25/+ | — | 50/+ |
| *Solidago decumbens* | — | 25/+ | 60/+ | — |
| *Thermopsis divaricarpa* | 75/+ | — | — | — |
| *Vicia americana* | — | 50/5 | — | — |

[1]*Coverage less than 0.5%.*

Table A-8.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Picea engelmannii/Trifolium dasyphyllum.*

| Species | *Picea/ Trifolium* (4 stands) |
|---|---|
| Low Shrubs | |
| *Vaccinium scoparium* | 50/ + |
| Graminoids | |
| *Calamagrostis purpurascens* | 25/ + |
| *Festuca brachyphylla* | 75/ + |
| *Poa interior* | 50/ + |
| *Trisetum spicatum* | 100/ + |
| Forbs | |
| *Achillea lanulosa* | 25/ + |
| *Antennaria parvifolia* | 25/ + |
| *Arenaria fendleri* | 75/ + |
| *Arenaria obtusiloba* | 50/ + |
| *Artemisia scopulorum* | 50/ + |
| *Epilobium angustifolium* | 25/ + |
| *Erigeron simplex* | 25/ + |
| *Geum rossii* | 25/ + |
| *Penstemon whippleanus* | 50/ + |
| *Polemonium delicatum* | 25/ + |
| *Polygonum bistortoides* | 50/ + |
| *Pyrola minor* | 100/1 |
| *Sedum stenopetalum* | 75/ + |
| *Senecio triangularis* | 25/ + |
| *Solidago ciliosa* | 50/ + |
| *Trifolium dasyphyllum* | 100/6 |
| *Trifolium parryi* | 100/3 |

[1]*Coverage less than 0.5%.*

Table A-9.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Abies lasiocarpa/Carex geyeri, A. lasiocarpa/Vaccinium scoparium, A. lasiocarpa/Senecio triangularis*, and *A. lasiocarpa/Calamagrostis canadensis.*

| Species | *Abies/ Carex* (4 stands) | *Abies/ Vaccinium* (5 stands) | *Abies/ Senecio* (4 stands) | *Abies/ Calamagrostis* (4 stands) |
|---|---|---|---|---|
| Medium Shrubs | | | | |
| *Lonicera involucrata* | — | 20/ + [1] | 50/ + | 100/2 |
| *Ribes lacustre* | — | 20/ + | 25/ + | 100/2 |
| Low Shrubs | | | | |
| *Pachistima myrsinites* | 75/1 | — | — | — |
| *Rosa woodsii* | 75/1 | 20/ + | — | 50/ + |
| *Vaccinium myrtillus* | — | 100/12 | 75/2 | 100/2 |
| *Vaccinium scoparium* | 75/2 | 100/54 | 75/4 | 100/3 |
| Graminoids | | | | |
| *Bromus anomalus* | 25/ + | 20/ + | 25/ + | 50/ + |
| *Calamagrostis canadensis* | — | 20/ + | 75/1 | 100/33 |
| *Carex aquatilis* | — | — | 75/1 | 100/10 |
| *Carex disperma* | — | — | 75/ + | 75/1 |
| *Carex festivella* | — | — | — | 75/ + |
| *Carex geyeri* | 100/23 | 20/ + | — | — |
| *Carex media* | — | — | 25/ + | 75/ + |
| *Carex microptera* | — | — | — | 50/ + |
| *Carex rossii* | 25/ + | 40/ + | — | — |
| *Juncus drummondii* | — | — | 50/1 | 50/ + |
| *Juncus ensifolius* | — | — | — | 50/ + |
| *Luzula parviflora* | — | 20/ + | 75/ + | 75/1 |
| *Poa interior* | 25/ + | 40/ + | — | — |
| *Poa reflexa* | — | — | — | 75/ + |
| *Trisetum spicatum* | — | 40/ + | 25/ + | 25/ + |

| | | | | |
|---|---|---|---|---|
| Forbs | | | | |
| *Achillea lanulosa* | 25/ + | — | 50/ + | — |
| *Aconitum columbianum* | — | 20/ + | 25/ + | 75/1 |
| *Angelica grayi* | — | — | 50/1 | 25/ + |
| *Arnica cordifolia* | 100/3 | 100/4 | 100/5 | 100/1 |
| *Arnica mollis* | — | — | 50/1 | — |
| *Artemisia scopulorum* | — | 20/ + | — | — |
| *Caltha leptosepala* | — | — | 75/10 | 75/3 |
| *Cardamine cordifolia* | — | — | 25/ + | 50/1 |
| *Castilleja miniata* | — | 40/ + | — | — |
| *Delphinium occidentale* | — | 20/ + | 25/ + | 50/1 |
| *Epilobium angustifolium* | — | 60/ + | 25/ + | 100/1 |
| *Epilobium hornemannii* | — | — | 25/ + | 50/ + |
| *Equisetum arvense* | — | — | 50/3 | 100/10 |
| *Erigeron peregrinus* | — | 40/ + | 50/1 | 25/ + |
| *Fragaria ovalis* | 25/ + | — | 50/1 | 50/1 |
| *Galium boreale* | 50/ + | — | — | 50/ + |
| *Geranium richardsonii* | 25/ + | — | 50/1 | 50/2 |
| *Habenaria hyperborea* | — | — | 50/ + | 75/1 |
| *Haplopappus parryi* | 75/1 | — | — | — |
| *Heracleum lanatum* | — | — | 25/ + | 75/1 |
| *Lathyrus leucanthus* | 75/1 | — | — | — |
| *Ligusticum porteri* | — | — | — | 50/2 |
| *Mertensia ciliata* | — | 20/ + | 75/1 | 100/2 |
| *Mitella pentandra* | — | — | 100/1 | 100/1 |
| *Moneses uniflora* | — | 20/ + | 75/1 | 50/ + |
| *Montia chamissoi* | — | — | 25/ + | 50/1 |
| *Osmorhiza depauperata* | — | 40/ + | 75/1 | 100/1 |
| *Pedicularis bracteosa* | — | 40/1 | 25/ + | 25/ + |
| *Pedicularis groenlandica* | — | — | 25/ + | 50/ + |
| *Pedicularis racemosa* | — | 40/1 | — | — |
| *Penstemon whippleanus* | 25/ + | — | — | — |
| *Polemonium delicatum* | 25/ + | 60/1 | 50/ + | — |
| *Polygonum bistortoides* | — | — | 50/ + | 25/ + |
| *Polygonum viviparum* | — | — | 50/1 | 25/ + |
| *Potentilla diversifolia* | 25/ + | — | 50/ + | — |
| *Primula parryi* | — | 20/ + | 50/ + | 50/1 |
| *Pyrola asarifolia* | — | — | 50/ + | 50/ + |
| *Pyrola chlorantha* | — | 20/ + | 50/1 | 100/1 |
| *Pyrola minor* | 25/ + | — | — | — |
| *Pyrola secunda* | — | — | 25/ + | 50/ + |
| *Saxifraga arguta* | — | — | 50/3 | 100/8 |
| *Sedum rhodanthum* | — | — | 50/ + | 25/ + |
| *Senecio triangularis* | — | — | 100/24 | 100/2 |
| *Sibbaldia procumbens* | — | 20/ + | — | — |
| *Smilacina stellata* | — | — | 50/2 | 100/2 |
| *Swertia perennis* | — | — | 50/ + | 25/ + |
| *Thalictrum fendleri* | 50/ + | — | — | — |
| *Trollius laxus* | — | — | 100/3 | 50/ + |
| *Veronica americana* | — | — | — | 50/ + |
| *Veronica wormskjoldii* | — | — | 100/1 | 75/ + |
| *Vicia americana* | 50/ + | — | — | — |
| *Zigadenus elegans* | — | — | 25/ + | 50/ + |

[1]*Coverage less than 0.5%.*

Table A-10.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Pinus aristata/Trifolium dasyphyllum*.

| Species | *Pinus/ Trifolium* (4 stands) |
|---|---|
| Medium Shrubs | |
| *Potentilla fruticosa* | 50/ +[1] |
| Graminoids | |
| *Agropyron scribneri* | 50/ + |
| *Calamagrostis purpurascens* | 100/ + |
| *Carex elynoides* | 75/1 |
| *Carex foenea* | 100/2 |
| *Festuca brachyphylla* | 75/ + |
| *Poa arctica* | 50/1 |
| *Poa interior* | 50/ + |
| *Poa lettermani* | 50/ + |
| *Poa pratensis* | 50/ + |
| *Poa stenantha* | 50/ + |
| *Trisetum spicatum* | 75/ + |
| Forbs | |
| *Achillea lanulosa* | 100/1 |
| *Allium geyeri* | 100/ + |
| *Arenaria fendleri* | 100/ + |
| *Artemisia scopulorum* | 100/ + |
| *Campanula rotundifolia* | 50/ + |
| *Epilobium angustifolium* | 100/ + |
| *Erigeron simplex* | 50/ + |
| *Erysimum nivale* | 50/ + |
| *Geum rossii* | 75/ + |
| *Mertensia viridis* | 50/ + |
| *Penstemon whippleanus* | 100/2 |
| *Polemonium delicatum* | 100/1 |
| *Sedum rosea* | 50/ + |
| *Sedum stenopetalum* | 100/1 |
| *Solidago decumbens* | 100/ + |
| *Trifolium dasyphyllum* | 100/11 |
| *Trifolium parryi* | 50/ + |

[1]*Coverage less than 0.5%.*

Table A-11.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Picea pungens/Arnica cordifolia.*

| **Species** | ***Picea/ Arnica*** **(4 stands)** |
|---|---|
| Medium Shrubs | |
| *Juniperus communis* | 100/1 |
| *Lonicera involucrata* | 50/+ |
| *Ribes inerme* | 50/1 |
| Low Shrubs | |
| *Arctostaphylos uva-ursi* | 50/+ [1] |
| *Rosa woodsii* | 100/2 |
| Graminoids | |
| *Agropyron trachycaulum* | 75/+ |
| *Bromus anomalus* | 75/+ |
| *Calamagrostis canadensis* | 50/+ |
| *Carex disperma* | 75/+ |
| *Carex foenea* | 75/1 |
| *Carex rossii* | 50/+ |
| *Luzula parviflora* | 50/+ |
| *Oryzopsis asperifolia* | 75/+ |
| *Poa interior* | 50/+ |
| Forbs | |
| *Achillea lanulosa* | 100/1 |
| *Aconitum columbianum* | 50/+ |
| *Aquilegia caerulea* | 50/+ |
| *Arnica cordifolia* | 100/18 |
| *Campanula rotundifolia* | 50/+ |
| *Equisetum arvense* | 75/+ |
| *Fragaria ovalis* | 100/1 |
| *Galium boreale* | 100/1 |
| *Geranium richardsonii* | 75/1 |
| *Haplopappus parryi* | 50/+ |
| *Hydrophyllum capitatum* | 75/1 |
| *Ligusticum porteri* | 50/1 |
| *Osmorhiza depauperata* | 100/1 |
| *Pseudocymopterus montanus* | 75/1 |
| *Smilacina stellata* | 100/1 |
| *Taraxacum officinale* | 75/1 |
| *Thalictrum fendleri* | 50/1 |

[1]*Coverage less than 0.5%.*

Table A-12.—Constancy and mean canopy coverage (percent) of undergrowth species in stands of *Populus angustifolia/Salix exigua.*

| **Species** | ***Populus/ Salix* (4 stands)** |
|---|---|
| Tall Shrubs | |
| *Alnus tenuifolia* | 100/7 |
| *Betula occidentalis* | 75/3 |
| *Cornus stolonifera* | 75/9 |
| *Salix caudata* | 75/5 |
| *Salix exigua* | 100/12 |
| *Salix lasiandra* | 50/3 |
| *Salix monticola* | 75/4 |
| Low Shrubs | |
| *Ribes inerme* | 50/4 |
| *Rosa woodsii* | 100/5 |
| *Symphoricarpos occidentalis* | 50/5 |
| Graminoids | |
| *Agropyron trachycaulum* | 75/+[1] |
| *Bromus anomalus* | 75/1 |
| *Calamagrostis canadensis* | 100/23 |
| *Carex* spp. | 50/6 |
| *Carex festivella* | 50/+ |
| *Carex lanuginosa* | 50/+ |
| *Phleum pratensis* | 75/1 |
| *Poa interior* | 50/1 |
| *Poa pratensis* | 100/3 |
| Forbs | |
| *Achillea lanulosa* | 50/1 |
| *Aster* spp. | 50/3 |
| *Campanula rotundifolia* | 50/+ |
| *Castilleja septentrionalis* | 50/1 |
| *Clematis ligusticifolia* | 75/+ |
| *Cystopteris fragilis* | 50/1 |
| *Dodecatheon pulchellum* | 50/+ |
| *Equisetum arvense* | 75/2 |
| *Erigeron speciosus* | 50/+ |
| *Fragaria ovalis* | 50/+ |
| *Galium boreale* | 100/2 |
| *Geranium richardsonii* | 50/1 |
| *Habenaria hyperborea* | 50/1 |
| *Heracleum lanatum* | 100/1 |
| *Mentha arvensis* | 75/1 |
| *Osmorhiza depauperata* | 50/+ |
| *Penstemon angustifolius* | 50/1 |
| *Polygonum viviparum* | 50/1 |
| *Rudbeckia laciniata* | 75/1 |
| *Senecio serra* | 75/1 |
| *Senecio wootonii* | 50/+ |
| *Smilacina stellata* | 100/6 |
| *Taraxacum officinale* | 100/1 |
| *Thalictrum fendleri* | 50/6 |
| *Thermopsis divaricarpa* | 50/2 |
| *Trifolium repens* | 50/+ |
| *Vicia americana* | 100/5 |

[1]*Coverage less than 0.5%.*

Hess, Karl and Robert R. Alexander. 1986. Forest vegetation of the Arapaho and Roosevelt National Forests in north-central Colorado: A habitat type classification. USDA Forest Service Research Paper or General Technical Report RM–266, 48 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

A vegetation classification based on concepts and methods developed by Daubenmire and refined by others were used to identify 30 forest habitat types on the Arapaho and Roosevelt National Forests. Included were five habitat types in the *Pinus ponderosa* series; four each in the *Pseudotsuga menziesii*, *Pinus contorta*, and *Abies lasiocarpa* series; three each in the *Juniperus scopulorum*, *Pinus flexilis*, and *Populus tremuloides* series; and one each in the *Populus angustifolia*, *Picea pungens*, *Picea engelmannii*, and *Pinus aristata* series. A key to identify the habitat types and the management implications associated with each are provided.

**Keywords:** Vegetation classification, habitat type, *Pinus aristata*, *Picea engelmannii*, *Abies lasiocarpa*, *Pinus contorta*, *Populus tremuloides*, *Pinus flexilis*, *Picea pungens*, *Populus angustifolia*, *Pseudotsuga menziesii*, *Pinus ponderosa*, *Juniperus scopulorum*

Hess, Karl and Robert R. Alexander. 1986. Forest vegetation of the Arapaho and Roosevelt National Forests in north-central Colorado: A habitat type classification. USDA Forest Service Research Paper or General Technical Report RM–266, 48 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

A vegetation classification based on concepts and methods developed by Daubenmire and refined by others were used to identify 30 forest habitat types on the Arapaho and Roosevelt National Forests. Included were five habitat types in the *Pinus ponderosa* series; four each in the *Pseudotsuga menziesii*, *Pinus contorta*, and *Abies lasiocarpa* series; three each in the *Juniperus scopulorum*, *Pinus flexilis*, and *Populus tremuloides* series; and one each in the *Populus angustifolia*, *Picea pungens*, *Picea engelmannii*, and *Pinus aristata* series. A key to identify the habitat types and the management implications associated with each are provided.

**Keywords:** Vegetation classification, habitat type, *Pinus aristata*, *Picea engelmannii*, *Abies lasiocarpa*, *Pinus contorta*, *Populus tremuloides*, *Pinus flexilis*, *Picea pungens*, *Populus angustifolia*, *Pseudotsuga menziesii*, *Pinus ponderosa*, *Juniperus scopulorum*

Hess, Karl and Robert R. Alexander. 1986. Forest vegetation of the Arapaho and Roosevelt National Forests in north-central Colorado: A habitat type classification. USDA Forest Service Research Paper or General Technical Report RM–266, 48 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

A vegetation classification based on concepts and methods developed by Daubenmire and refined by others were used to identify 30 forest habitat types on the Arapaho and Roosevelt National Forests. Included were five habitat types in the *Pinus ponderosa* series; four each in the *Pseudotsuga menziesii*, *Pinus contorta*, and *Abies lasiocarpa* series; three each in the *Juniperus scopulorum*, *Pinus flexilis*, and *Populus tremuloides* series; and one each in the *Populus angustifolia*, *Picea pungens*, *Picea engelmannii*, and *Pinus aristata* series. A key to identify the habitat types and the management implications associated with each are provided.

**Keywords:** Vegetation classification, habitat type, *Pinus aristata*, *Picea engelmannii*, *Abies lasiocarpa*, *Pinus contorta*, *Populus tremuloides*, *Pinus flexilis*, *Picea pungens*, *Populus angustifolia*, *Pseudotsuga menziesii*, *Pinus ponderosa*, *Juniperus scopulorum*

Hess, Karl and Robert R. Alexander. 1986. Forest vegetation of the Arapaho and Roosevelt National Forests in north-central Colorado: A habitat type classification. USDA Forest Service Research Paper or General Technical Report RM–266, 48 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

A vegetation classification based on concepts and methods developed by Daubenmire and refined by others were used to identify 30 forest habitat types on the Arapaho and Roosevelt National Forests. Included were five habitat types in the *Pinus ponderosa* series; four each in the *Pseudotsuga menziesii*, *Pinus contorta*, and *Abies lasiocarpa* series; three each in the *Juniperus scopulorum*, *Pinus flexilis*, and *Populus tremuloides* series; and one each in the *Populus angustifolia*, *Picea pungens*, *Picea engelmannii*, and *Pinus aristata* series. A key to identify the habitat types and the management implications associated with each are provided.

**Keywords:** Vegetation classification, habitat type, *Pinus aristata*, *Picea engelmannii*, *Abies lasiocarpa*, *Pinus contorta*, *Populus tremuloides*, *Pinus flexilis*, *Picea pungens*, *Populus angustifolia*, *Pseudotsuga menziesii*, *Pinus ponderosa*, *Juniperus scopulorum*

U.S. Department of Agriculture
Forest Service

# Rocky Mountain Forest and Range Experiment Station

Rocky Mountains

Southwest

Great Plains

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

## RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

## RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico
Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Rapid City, South Dakota
Tempe, Arizona

*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526